Министерство здравоохранения республики Беларусь
УО «Витебский государственный медицинский университет»

L.G. Hidranovich, O.A. Khodos

ЛАБОРАТОРНЫЕ ЗАНЯТИЯ ПО БИООРГАНИЧЕСКОЙ ХИМИИ

LABORATORY CLASSES IN BIOORGANIC CHEMISTRY

учебно-методическое пособие

Рекомендовано учебно-методическим объединением по высшему медицинскому, фармацевтическому образованию в качестве учебно-методического пособия для студентов учреждений высшего образования, обучающихся на английском языке по специальности 1-79 01 07 «Стоматология»

Витебск
2017

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Авторы: Л.Г. Гидранович, О.А. Ходос

Рецензенты: Зав. кафедрой химии УО «Витебская ордена «Знак Почета» государственная академия ветеринарной медицины», к.б.н., доцент В.П. Баран.
Кафедра биоорганической химии УО «Белорусский государственный медицинский университет» (зав. каф. – к.м.н., доцент О.Н. Ринейская).

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Учебно-методическое пособие написано в соответствии с типовой учебной программой по биоорганической химии для студентов высших медицинских учреждений образования. Предназначена для освоения дисциплины «Биоорганическая химия» студентами 1 курса стоматологического факультета на английском языке.

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10	Organic compounds in stomatology.

THEMATIC PLAN
OF LABORATORY CLASSES IN BIOORGANIC CHEMISTRY

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2	Electronic structure of chemical bonds. Inductive and resonance effects.
3	Stereochemistry of organic compounds. Configuration and conformation of the organic compounds.
4	Classification and mechanisms of the reactions in organic chemistry. Saturated, unsaturated and aromatic hydrocarbons. S_R, S_E, A_E reactions. Laboratory work.
5	Acid-base properties of organic compounds. Laboratory work.
6	Alcohols, phenols, thiols, amines. S_N and E reaction. Laboratory work
7	Carbonyl compounds. Aldehydes, ketones A_N reactions. Laboratory work.
8	Carboxylic acids and derivatives. S_N reactions. Laboratory work.
9	Poly- and heterofunctionality as one of characteristic signs of organic compounds. Laboratory work.
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12	Carbohydrates. Oligosaccharides and polysaccharides. Laboratory work.
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ACCIDENT PREVENTION.

1. Make all laboratory experiments with little quantity of substances. Strictly observe methods of the experiments.
2. It is categorically forbidden to taste chemical substances and take them with hands. Smell chemical substances very carefully directing the air from the aperture of the test-tube towards the nose by hand movement.
3. Use only clean and dry test-tubes for the experiments.
4. Warm the test-tube gradually and carefully. Use the test-tube holder to warm the test-tube. Don't direct the aperture of the test-tube to yourself or other students.
5. Carry out all experiments with concentrated acids and bases in the exhaust-hood. Don't admit them to be hitted on the skin to avoid the burn.
6. Carry out the experiments with volatile and flammable liquids (benzene, acetone, ethyl ethanoat, ethoxyethane) in the exhaust-hood far from the fire and working hot plates. Don't inhale vapour of volatile compounds to avoid the poisoning.
7. Take no risks with toxic substances (benzene, toluol, aniline, benzaldehyde, hydroxylamine). Don't inhale their vapour, avoid hitting the skin.
8. Don't pour concentrated acids, bases and reaction mixtures in the wash-bowl. Pour them into the special phial.
9. Inform the teacher if the accident took place. Use the first-aid kit in the laboratory or see a doctor.

THEME 1

Classification and IUPAC nomenclature of organic compounds.

1. Program questions:

1.1. Representation of structural formulas.

1.2. Classification of the organic compounds according to the structure of carbon skeleton and according to the functional groups.

1.3. Classification of carbon atoms.

1.4. Alkyl groups.

1.5. IUPAC nomenclature of organic compounds. The parent structure, senior group, locants, prefixes and suffixes.

Literature:

[1] L.G. Hidranovich. Bioorganic chemistry lecture course. Vitebsk, 2004. p. 4 – 16

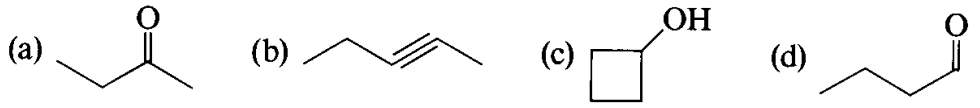
[2] T.W. Graham Solomons. Fundamentals of organic chemistry. John Willey and sons, 1994. p. 116 – 127, 501 - 504, 643 - 644, 715 - 723, 770 - 772

[3] George H. Schmid. Organic chemistry. Mosby, 1996. p. 57 – 70, 76 - 82, 451 - 454, 550 - 553, 591 - 594, 652 - 656, 699 -702, 963 - 966

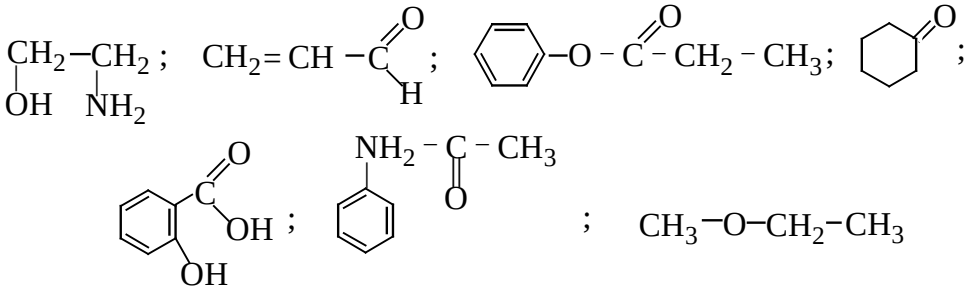
[4] Richard F. Daley, Sally J. Dalley. Organic chemistry Wm. C. Brown Publishers, 1996. p. 73 - 111

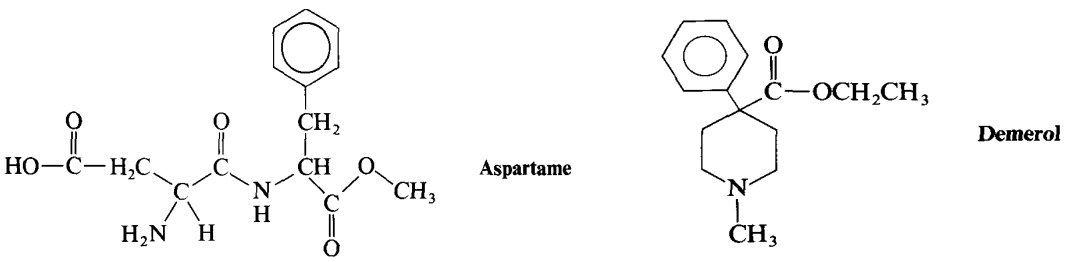
2. Problems.

1. Convert the line structures of following compounds to the condensed structures.



2. Classify each of the following compounds as an alkane, alkene, alkyne, alcohol, aldehyde, amine and so forth.

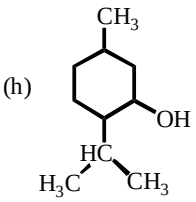
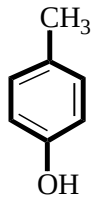
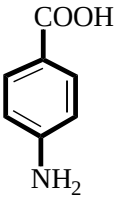
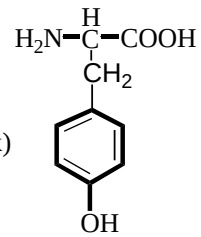
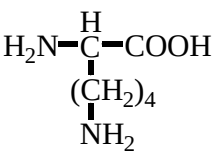




3. Write structural formulas for each of the following:

(a) Three ethers with the formula **$C_4H_{10}O$**.
(b) Three primary alcohols with the formula **C_4H_8O.**
(c) A secondary alcohol with the formula **C_3H_6O**.
(d) A tertiary alcohol with the formula **C_4H_8O.**
(e) Two esters with the formula **$C_3H_6O_2$.**
(f) Four primary alkyl halides **with** the formula **$C_5H_{11}Br$**.
(g) Three secondary alkyl halides with the formula **$C_5H_{11}Br$**.
(h) A tertiary alkyl halide with the formula **$C_5H_{11}Br$**.
(i) Three aldehydes with the formula **$C_5H_{10}O$**.
(j) Three ketones with the formula **$C_5H_{10}O$.**
(k) Two primary amines with the formula **$C_3H_{11}N$**.
(1) A secondary amine with the formula **$C_3H_{11}N$**.
(m) A tertiary amine with the formula **$C_3H_{11}N$**.
(n) Two amides with the formula **C_2H_5NO**.

4. Give systematic IUPAC names for each of the following:

(a) CH_3-CH_2-CH_2-OH
(b) CH_3-CH_2-I
(c) CH_3-CH_2-O-CH_2-CH_2-CH_3
(d) CH_3-S-CH_2-CH_2-CH_3
(f) CH_3-C(=O)-O-CH_2-CH_2-CH_3
CH_3-CH_2-CH_2-COOH
(g) CH_3-C(=O)-CH_2-COOH
(h) 
(i) 
(j) 
(k) 
(l) 

5. Write a structural formula for each of the following compounds:

(a) 4-isopropylheptane
(b) 4-methylpentanol-2
(c) 5,6-dichlorocyclohexene
(d) 2-chlorohexyn-3-ol-1

(e) 2-phenylethanol
(f) 4-nitrobenzoic acid
(g) 2,4,6-trinitrophenol
(h) Benzoyl chloride
(i) 2-amino-1-(3,4-dihydroxyphenyl)-ethanol-1
(j) N,N-diethylhexanamide
(k) Methyl benzoate

THEME 2
Electronic structure of chemical bonds. Inductive and resonance effects.

1. Program questions:

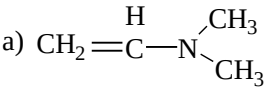
1. Hybridization of carbon atom.
1. Chemical bonding in organic compounds.
2.1. Covalent bond formation.
2.2. Non-polar covalent bonds (carbon-carbon single, double and triple bonds).
2.3. Polar covalent bonds.
2.4. Ionic bonds.
3. Intermolecular forces.
4. Inductive effects on bond polarity.
5. Conjugation. Electron structure of π, π and p, π conjugated systems.
6. Resonance (mesomeric) effect.

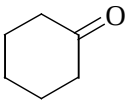
Literature:

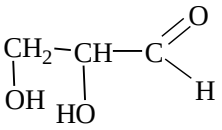
[1] L.G. Hidranovich. Bioorganic chemistry lecture course. Vitebsk, 2004. p. 16 – 33
[2] T.W. Graham Solomons. Fundamentals of organic chemistry. John Willey and sons, 1994. p. 27 - 52
[3] George H. Schmid. Organic chemistry. Mosby, 1996. p. 17 – 44
[4] Richard F. Daley, Sally J. Dalley. Organic chemistry Wm. C. Brown Publishers, 1996. p. 34 – 65.

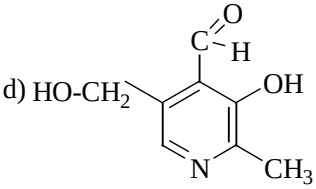
2. Problems.

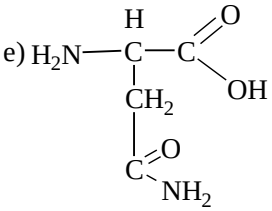
1. Define the hybridization type of carbon atoms and heteroatoms (pyridine and pyrrole type) in following compounds:

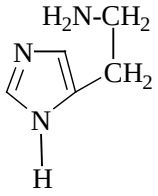
a) 

b) 

c) 

d) 

e) 

f) 

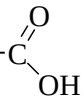
2. Find the conjugation in following compounds, define the type of conjugation and show the electronic structure of conjugated systems. Designate electron's movement with curved arrows.

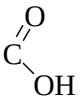
a) CH_2=CH-CH_3

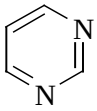
b) CH_2=CH-CH=CH-CH_3

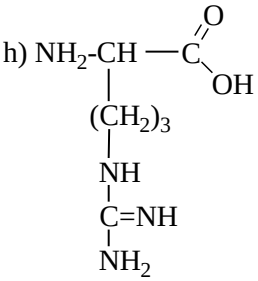
c) CH_2=CH-CH_2-CH=CH_2

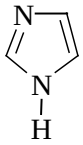
d) CH_2=CH-O-CH_3

e) CH_3-CH_2-CH_2 

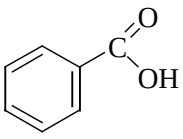
f) CH_2=CH 

g) 

h) 

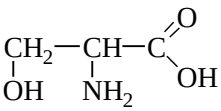
i) 

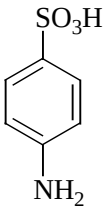
3. Define the sign (negative or positive) of inductive and resonance effects of functional groups and heteroatoms in following compounds. Show these effects with arrows.

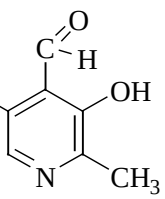
a) 

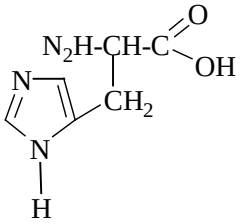
b) CH_3-CH_2-O-CH_3

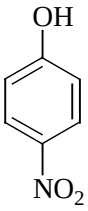
c) CH_2=CH-Cl

d) 

e) 

f) HO-CH_2 

g) 

h) 

THEME 3
Stereochemistry of organic compounds.
Configuration and conformation of organic compounds.

1. Program questions:

1. Conformation. Newman projection formulas. Conformation analysis. Conformations of ethane and butane.

2. Conformations of cyclohexane. Chair conformations. Conformational inversion of cyclohexane. Conformational analysis of substituted cyclohexanes.

3. Stereoisomerism, configuration. Stereocenter. Enantiomers and diastereomers.

4. Fischer projection formulas. Molecules with one and more than one stereocenters.

5. Naming of enantiomers: the (D-L-) and (R-S-) systems.

6. Mesocompounds.

Literature:

[1] L.G. Hidranovich. Bioorganic chemistry lecture course. Vitebsk, 2004. p. 33 - 54

[2] T.W. Graham Solomons. Fundamentals of organic chemistry. John Willey and sons, 1994. p. 164 - 198

[3] George H. Schmid. Organic chemistry. Mosby, 1996. p. 128 – 163, 226 – 271

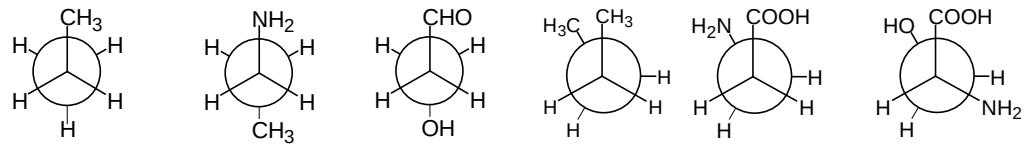
[4] Richard F. Daley, Sally J. Dalley. Organic chemistry Wm. C. Brown Publishers, 1996. p. 128 – 153, 162 – 163, 510 - 537

2. Problems.

1. Write the Newman projection formulas of all staggered and eclipsed conformations for:

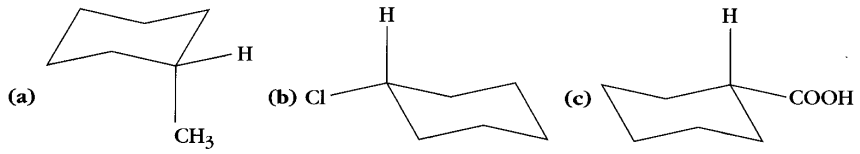
a. 1,2-diiodoethane;
b. 2-methylbutane (along C2–C3 bond);
c. 2-aminoethanol
d. butandioic acid (along C2–C3 bond)

2. Write the condensed structural formulas of each of the following:

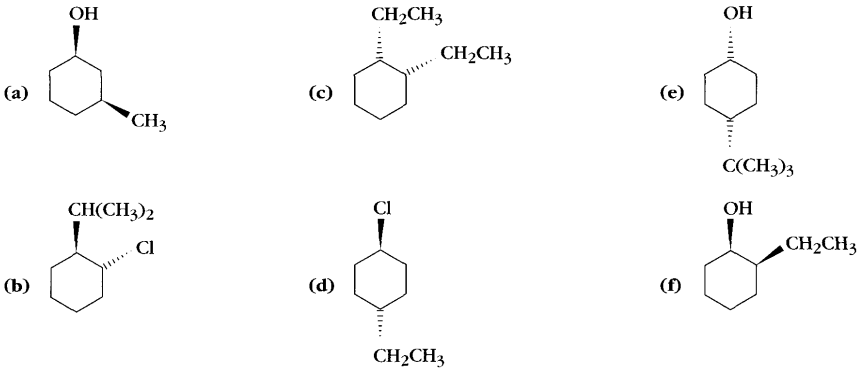


a. b. c. d. e. f.

3. In each of the following structures, indicate whether the substituent is in an axial or an equatorial position.



4. Convert each of the following structures into its two chair conformations. In each case indicate which one should be the more stable conformation.



5. Write the structure of the preferred conformation of:

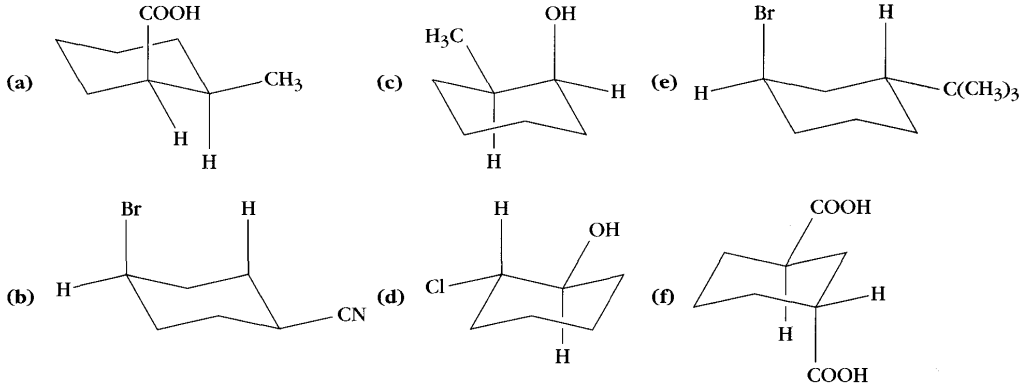
(a) 1-Isopropyl-2-methylcyclohexane

(b) cis-1-Bromo-2-isopropylcyclohexane

(c) trans-1-Methyl-3-isopropylcyclohexane

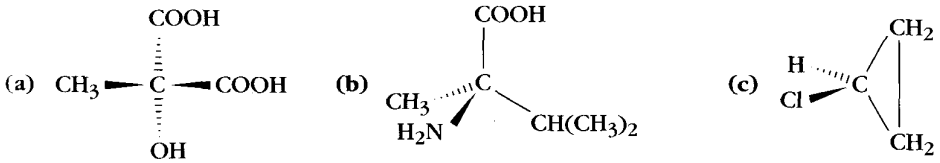
(d) cis-1-Chloro-4-isopropylcyclohexane

6. Identify each of the following compounds as either the *cis*- or the trans-isomer:



7. Write the two chair conformations of all trans-1,2,3,4,5,6-hexachlorocyclohexane.

8. The following three-dimensional structures represent one particular stereoisomer. Which would you expect to be optically active?



9. Draw the standard Fischer projection formulas of stereoisomers that correspond to each of the following compounds. Indicate enantiomers and diastereoisomers.

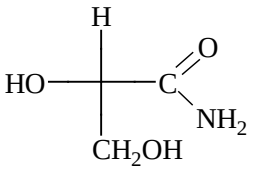
a) 2-hydroxypropanal;

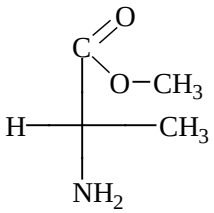
b) 2-aminopropanoic acid;

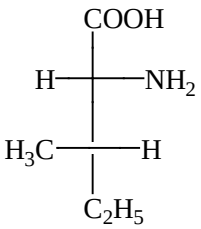
c) 2-amino-3-hydroxybutanoic acid;

d) 2,3-dihydroxybutandioic acid.

10. Assign the R os S and D or L configuration to the stereocenter in each of the following:

a) 

b) 

c) 

THEME 4
Classification and mechanisms of reactions in organic chemistry. Saturated, unsaturated and aromatic hydrocarbons. S_R, S_E, A_E reactions.

1. Program questions:

1. Homolysis and heterolysis of covalent bonds. Ionic and radical reactions.

2. Reactive intermediates in organic chemistry.

3. Organic reaction terminology. Classification of reagents in organic reactions. Substitution, addition and elimination reactions.

4. Classification of the hydrocarbons.

5. Reactions of alkanes and cycloalcanes (common cycles). S_R reactions.

6. Reactions of alkenes and alkadienes. A_E reactions: hydrohalogenation, hydration. Markovnikov's rule. Addition reactions of conjugated alkadienes.

7. Reactions of aromatic hydrocarbons. S_E reactions. Halogenation, nitration, sulfonation, alkylation, acylation. Orientation rule in benzene ring.

Literature:

[1] L.G. Hidranovich. Bioorganic chemistry lecture course. Vitebsk, 2004. p. 75 - 91

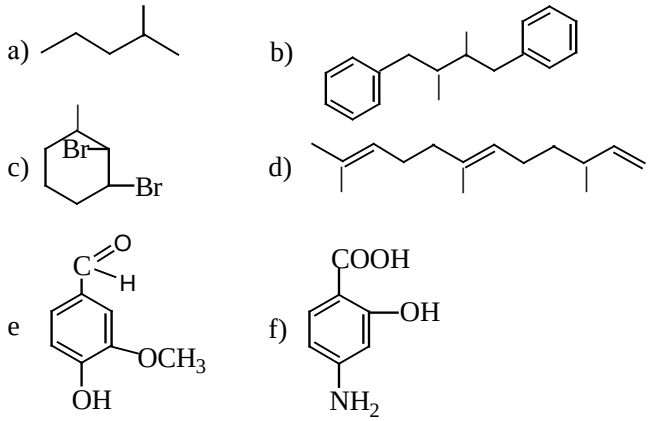
[2] T.W. Graham Solomons. Fundamentals of organic chemistry. John Willey and sons, 1994. p. 111-130, 152-153, 267-273, 297-314, 323-328, 340-354, 371-372, 500-519, 599-606, 614-627

[3] George H. Schmid. Organic chemistry. Mosby, 1996. p. 51-76, 277-290, 292-312, 368-372, 373-379, 381-388, 799-807, 885-895, 922-924, 929-954

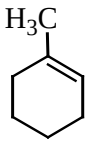
[4] Richard F. Daley, Sally J. Dalley. Organic chemistry Wm. C. Brown Publishers, 1996. p. 77-78, 1068-1072, 708-710, 714-715, 725-729, 690-702, 884-925, 839-866

2. Problems.

1. Give systematic IUPAC names for each of the following:



2. Write a structural formula for each of the following compounds:
   a) 2-methyl-4,4-diethylheptane;
   b) 2-isopropyl-5-methylcyclohexanol;
   c) trans-2,2,5,5-tetramethylhexene-3;
   d) 2,4,6-trinitrophenol;
   e) 3,4,5-trihydroxybenzoic acid;
   f) pentadiene-1,3.
3. Write the products formed in reactions of Br_2 with following compounds:
   a) ethane;
   b) 2-methylpropane;
   c) methylcyclohexane;
   d) 3-ethylpentane;
4. Draw all possible monochlorination products from the radical chlorination of 2,2,4-trimethylpentane. Estimate approximately the amounts of each isomer of product that forms.
5. Write structures and names of the product or products expected from the addition of HCl and H_2O to each of the following compounds:
   a) methylpropene;
   b) 3-methyl-butene-1;
   c) $H_2C = \underset{\displaystyle CH_3}{\overset{\displaystyle |}{C}}\text{-}CH_2\text{-}CH_2\text{-}CH_3$

d) 

e) $H_2C = CHBr$

f) $CH_3\text{-}CH{=}CH\text{-}C(=O)OH$

g) $HOOC\text{-}CH{=}C(COOH)\text{-}CH_2\text{-}COOH$

6. What reaction products, if any, result from the reaction of cyclohexene with the following reagents?

a) H_2 (Pt);
b) Br_2;
c) $KMnO_4$;
d) HBr.

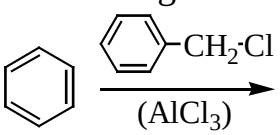
7. Predict the major mononitration products from each of the following aromatic compounds:

a) Toluene;
b) Benzoic acid;
c) 1,3-dimethylbenzene;
d) 4-methylphenol;
e) 4-ethylbenzoic acid.

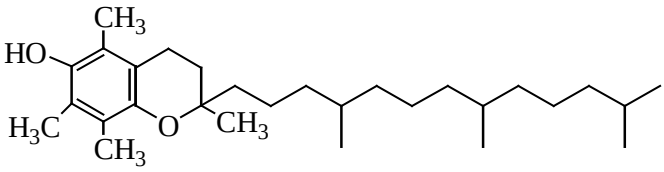
8. Predict the major products of the monosulphonation of the following substances:

a) phenol;
b) methoxybenzene;
c) nitrobenzene;
d) bromobenzene;
e) 3-nitrobenzoic acid.

9. What product is formed in the following reaction?



10. Vitamin E is an important antioxidant that prevents the formation of hydroperoxides in unsaturated fatty acids. Vitamin E is found most abundantly in oil seeds rich in these unsaturated fatty acids. Chemists postulate that vitamin E inhibits radical degradation of cellular materials. If true, vitamin E might slow the aging process in mammals. Show how vitamin E might be a radical chain inhibitor.



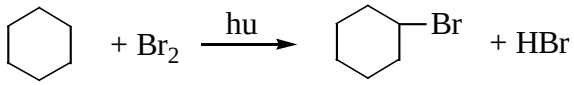
3. Laboratory work:

Experiment № 1. Reaction of alkanes with bromine water.

Sequence of operations: Place 3 ml of cyclohexane in two test-tubes. Add 4 drops of the bromine in CCl_4 solution. Keep the test-tube № 1 on the light and the test-tube № 2 in the darkness during 1 or 2 days.

Check the result: the change of colour in test-tube № 1 .

Write:



cycloxexane

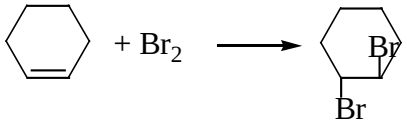
Explain the result and write conclusion.

Experiment № 2. Reaction of alkenes with bromine water.

Sequence of operations: Place 3 drops of bromine water in two test-tubes. Add one by one several drops of cyclohexene in the test-tube № 1 and several drops of cyclohexane in the test-tube № 2.

Check the result: the change of colour in the test-tube № 1.

Write:



cyclohexene

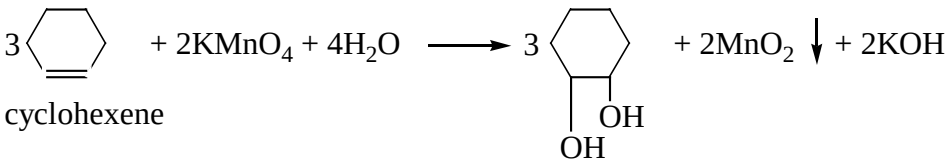
Explain the result and write conclusion.

Experiment № 3. Oxidation of alkenes by $KMnO_4$.

Sequence of operations: Place 2 drops of $KMnO_4$ solution in two test-tubes. Add one by one several drops of cyclohexene in the test-tube № 1 and several drops of cyclohexane in the test-tube № 2.

Check the result: the change of colour and brown precipitate in the test-tube № 1.

Write:



cyclohexene

Explain the result and write conclusion.

Experiment № 4. Reaction of benzene and toluene with bromine water and their oxidation by $KMnO_4$.

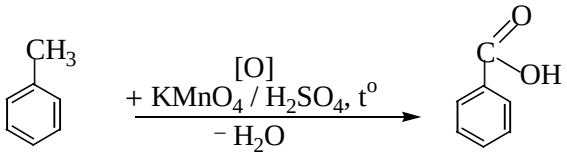
a) **Sequence of operations:** Place 2 drops of benzene in the test-tube № 1 and 2 drops of toluene in the test-tube № 2. Add 3 drops of bromine water in these test-tubes.

Check the result: there is no change of colour.

b) Sequence of operations: Place 2 drops of benzene in the test-tube № 1 and 2 drops of toluene in the test-tube № 2. Add 2 drops of $KMnO_4$ solution and 1 drop of H_2SO_4 in these test-tubes. Warm the test-tubes.

Check the result: the change of colour in the test-tube № 2.

Write:



toluene benzoic acid

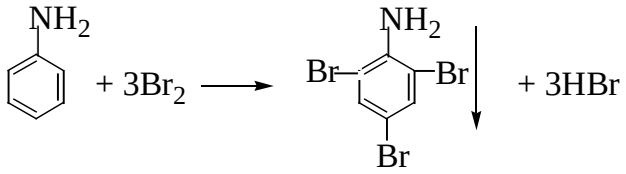
Explain the result and write conclusion.

Experiment № 5. Reaction of aniline with bromine water.

Sequence of operations: Place 1 drop of aniline and 6 drops of water in the test-tube. Shake the test-tube. Add 3 drops of bromine water.

Check the result: white precipitate.

Write:



aniline 2,4,6-tribromoaniline

Explain the result and write conclusion.

THEME 5
Acid-base properties of organic compounds.

1. Program questions:

1. The Brensted-Lowry definition of acids and bases.
2. The Lewis definition of acids and bases.
3. The strength of acids and bases: the acidity constant (Ka) and pKa.
4. Organic acids and bases. Relative acidity and basicity.
5. The relationship between structure and acidity. The effect of hybridization. Inductive effects (influence of electron attracting and electron donating groups).
6. The relationship between structure and basicity.

Literature:

[1] L.G. Hidranovich. Bioorganic chemistry lecture course. Vitebsk, 2004.

p. 54 - 74

[2] T.W. Graham Solomons. Fundamentals of organic chemistry. John Willey and sons, 1994. p. 86 – 102, 130 - 150

[3] George H. Schmid. Organic chemistry. Mosby, 1996. p. 88 – 103

[4] Richard F. Daley, Sally J. Dalley. Organic chemistry Wm. C. Brown Publishers, 1996. p. 206 - 234

2. Problems.

1. What is the conjugate base of each of the following acids?

a) N^+H_4

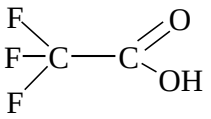
b) H_2O

c) $HC{\equiv}CH$

d) C_6H_5OH

e) H_3O^+

f) $CH_3 - C(=O)OH$

g) 

h) $CH_3 - N^+H_3$

2. List the bases you gave as answers to Problem 1 in decreasing order of basicity.

3. What is the conjugate acid of each of the following bases?

a) H^-

b) H_2O

c) CH_3NH_2

d) NH_2^-

e) $C_2H_5 - O^-$

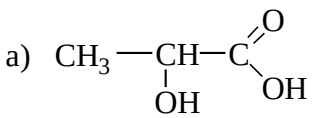
f) $CH_3CO_2^-$

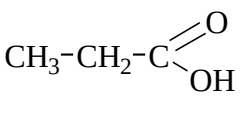
g) OH^-

h) NH_3

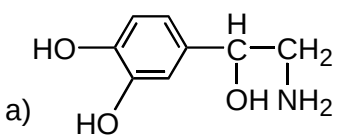
4. List the acids you gave as answers to Problem 3 in decreasing order of acidity.

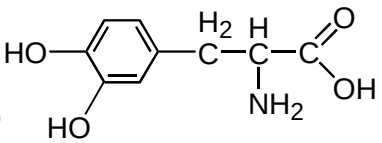
5. Compare the strength of acids:

a) 

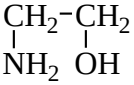
b) 

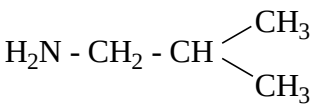
6. Compare the strength of acidic centers of each of the following acids.

a) 

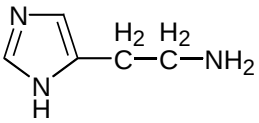
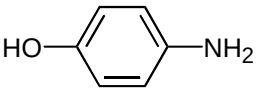
b) 

7. Compare the strength of bases:

a) 

b) 

8. Compare the strength of basic centers of each of the following bases.

a)  b) 

THEME 6
Alcohols, phenols, thiols, amines. S_N and E reactions.

1. Program questions:

1. Nomenclature of alcohols, ethers, thiols, phenols, amines.
2. Alcohols, thiols, phenols, amines as acids and bases.
3. Alkyl phosphates.
4. Reaction centres and reactions of alcohols. S_N1 and S_N2 reactions. Factors affecting the rates of S_N1 and S_N2 reactions. Conversion of alcohols in to alkyl halides. Alcohol dehydration. Synthesis of ethers.
5. Mechanism of alcohol dehydration: an E1 reaction (synthesis of alkenes).
6. Reactions of ethers.
7. Reactions of phenols. Formation of quinones by oxidation of phenols. Hydroquinone – quinone oxidation – reduction equilibria.
8. Reactions of thiols.
9. Classification and reaction centres of amines. Basic and nucleophilic properties of amines.

Literature:

[1] L.G. Hidranovich. Bioorganic chemistry lecture course. Vitebsk, 2004. p. 92 - 117

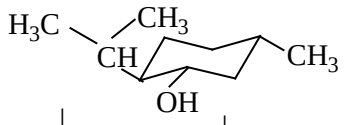
[2] T.W. Graham Solomons. Fundamentals of organic chemistry. John Willey and sons, 1994. p. 216-218, 227-242, 384-391, 400-403, 406-417, 433-444, 770-784, 792-797, 857-870, 872-873

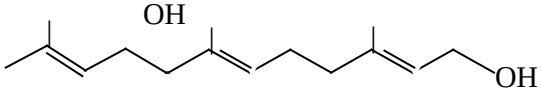
[3] George H. Schmid. Organic chemistry. Mosby, 1996. p. 451-455, 481-489, 505-540, 550-555, 557-560, 567-569, 963-969, 971-974, 986-990, 1015-1018, 1021-1031, 1033-1037

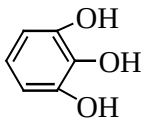
[4] Richard F. Daley, Sally J. Dalley. Organic chemistry Wm. C. Brown Publishers, 1996. p. 566-596, 631-643, 656-659, 305-310

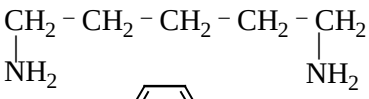
2. Problems.

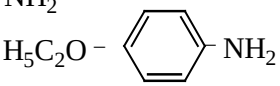
1. Give systematic IUPAC names for each of the following:

a) 

b) 

c) 

d) 

e) 

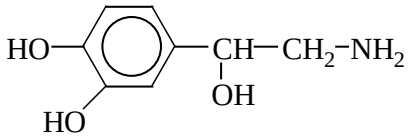
2. Write a structural formula for each of the following compounds:

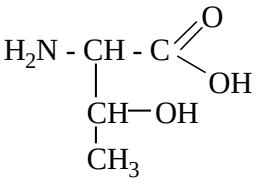
a) 2-ethoxypentane;
b) 2,2-dimethylpropanol-1;
c) 1,4-pentanediol;
d) 5-chloro-4-methylpentanol-2;
e) 1-cyclohexylbutanol-1;
f) N-ethyl-N-methylaniline;
g) 4-aminophenol;
h) ethylthioethane;
i) 2-amino-1-(3,4-dihydroxyphenyl)-ethanol-1.

3. Arrange each of the following sets of compounds in decreasing order of their expected acid strength in solution:

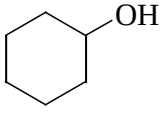
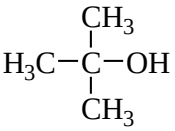
a) 2-chlorohexanol; 3-chlorohexanol; 4-chlorohexanol; 2,2-dichlorohexanol.
b) 2,2-dimethylbutanol-1: 2,2-dimethylbutanamine: butanol-1.

4. Find the reaction centres in following compounds. Write the schemes and outline mechanisms of possible reactions for these reaction centres.

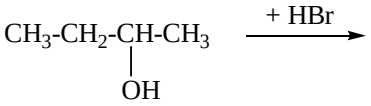
a) 

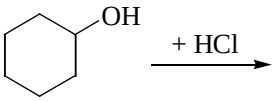
b) 

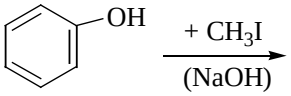
5. Rank the following compounds in order of increasing reactivity towards S_{N1} substitution. Then rank them in order of increasing reactivity towards S_{N2} subtitution.

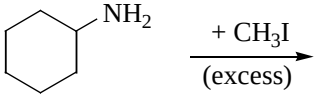
$(CH_3)_2CHCH_2OH$ CH_3-CH_2-OH  

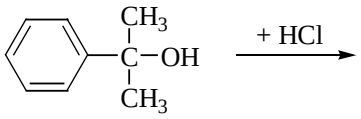
6. Predict the major products of each of the following reactions. Determine whether the reaction is primarily S_{N1} or S_{N2}.

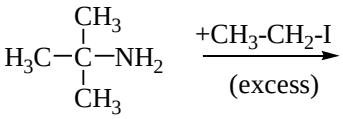
a) 

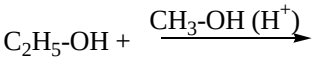
b) 

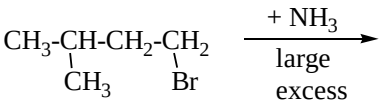
c) 

d) 

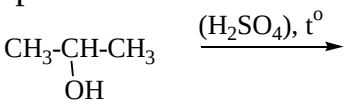
e) 

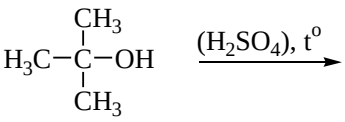
f) 

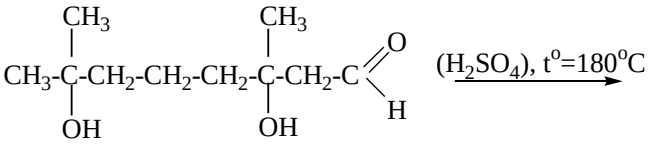
g) 

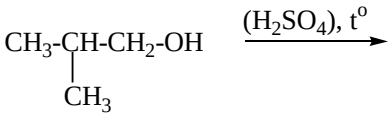
i) 

7. Draw the structure for the elimination product of each of the following reactions. Justify your product with a mechanism.

a) 

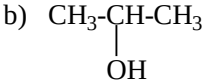
b) 

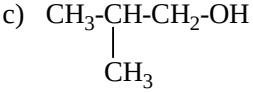
d) 

c) 

8. Write the schemes of the reactions that prove nucleophilic properties of following compounds.

a) CH_3-CH_2-CH_2-OH

b) 

c) 

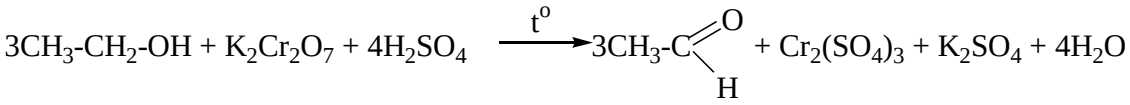
3. Laboratory work:

Experiment №1. Oxidation reaction of alcohol.

Sequence of operations: Place 2 drops of C_2H_5OH in the first test-tube. Add 2 drops of H_2SO_4 and 2 drops of $K_2Cr_2O_7$ solution. Warm the mixture.

Check the result: change of colour.

Write:



ethanol ethanal

Explain the result and write conclusion.

Experiment № 2. Reaction of glycerol with $Cu(OH)_2$.

Sequence of operations:

a) Place 3 drops of $CuSO_4$ solution and 3 drops of NaOH solution in the first and in the second test-tubes

Check the result: blue precipitate.

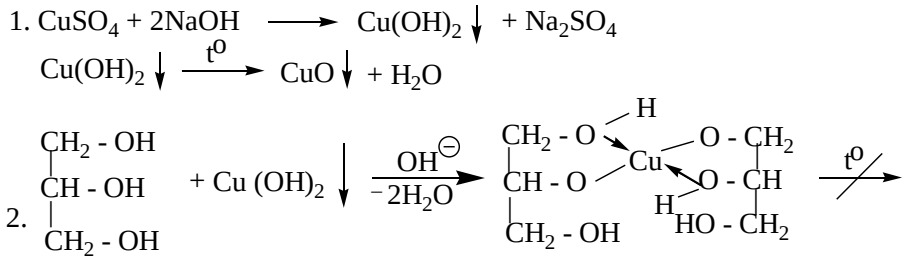
b) Add 2 drops of glycerol in the second test-tube.

Check the result: blue solution.

c) Warm the mixtures.

Check the result: black precipitate of CuO in the first test-tube and blue solution in the second test-tube.

Write:



glycerol copper glycerate

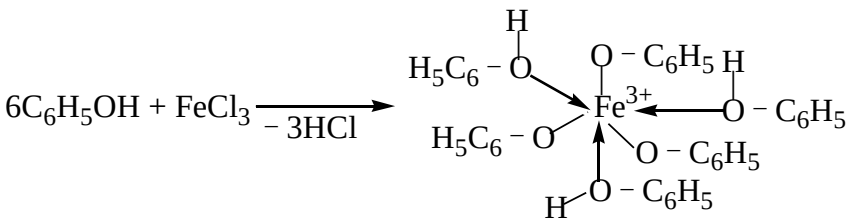
Explain the result and write conclusion.

Experiment № 3. Coloured reactions of phenols with $FeCl_3$.

Sequence of operations: Place 1 drop of $FeCl_3$ in the test-tube. Add 3 drops of the phenol in the test-tube.

Check the result: the change of colour.

Write:



Explain the result and write conclusion.

Experiment № 4. Formation of sodium phenoxide (C_6H_5ONa).

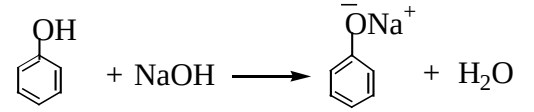
Sequence of operations: a) Place 3 drops of water and 2 drops of C_6H_5OH in the test-tube. Add several drops of NaOH solution.

Check the result: the formation of solution.

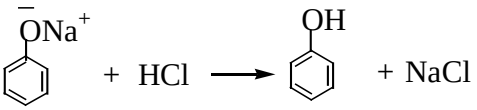
b) Add several drops of HCl solution.

Check the result: emulsion.

Write:



phenol — sodium phenoxide



sodium phenoxide — phenol

Explain the result and write conclusion.

Experiment № 5. Basicity of amines.

Sequence of operations:

a) Place 1 drop of methanamine (CH_3-NH_2) on the indicator paper.

Check the result: the change of colour.

b) Place 1 drop of aniline and 3 drops of water in the test-tube.

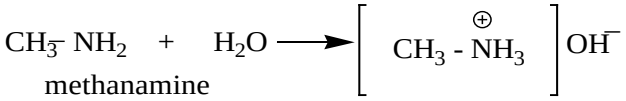
Place 1 drop of this solution on the indicator paper strip.

Check the result: there is no change of colour.

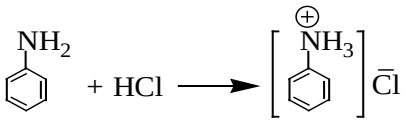
c) Place 1 drop of aniline and 3 drops of water in two test-tubes. Add 1 drop of HCl solution in the first test-tube and 1 drop of H_2SO_4 solution in the second test-tube.

Check the result: the solution in the first test-tube and the precipitate in the second test-tube.

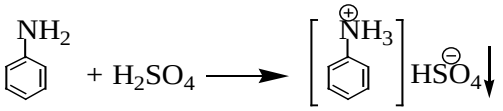
Write:



methanamine



aniline



aniline

Explain the result and write conclusion.

THEME 7
Carbonyl compounds. Aldehydes, ketones. A_N reactions.

1. Program questions:

1. Nomenclature of aldehydes and ketones.
2. Reaction centres of aldehydes and ketones.
3. Nucleophilic addition (A_N) to the carbon-oxygen double bond. The addition of water and alcohols: hydrates, hemiacetals, hemiketals, acetals and ketals. Thioacetals and thioketals.
4. The addition of derivatives of ammonia: A_N-E mechanism. Reactions with hydroxylamine, hydrazine, 2,4-dinitrophenylhydrazine.
5. Reactions of the α-CH acidic centre. Keto and enol tautomers. The iodoform test. The aldol reaction: the addition of enolate ions to aldehydes and ketones.
6. Oxidation of aldehydes and ketones. Tollen's test (silver mirror test), reaction with Fehling's solution. Disproportionation reaction.

Literature:

[1] L.G. Hidranovich. Bioorganic chemistry lecture course. Vitebsk, 2004. p. 117 - 135

[2] T.W. Graham Solomons. Fundamentals of organic chemistry. John Willey and sons, 1994. p. 642-646, 653-667, 674-676, 686-703

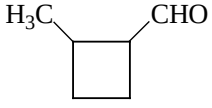
[3] George H. Schmid. Organic chemistry. Mosby, 1996. p. 589-598, 606-609, 611-624, 634-643

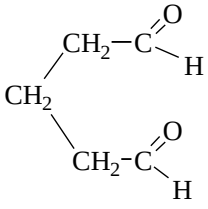
[4] Richard F. Daley, Sally J. Dalley. Organic chemistry Wm. C. Brown Publishers, 1996. p. 285 – 293, 297 - 310

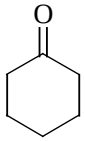
2. Problems.

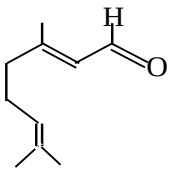
1. Give systematic IUPAC names for each of the following:

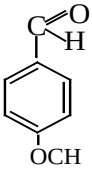
a) $(CH_3)_2CHCH_2CHO$

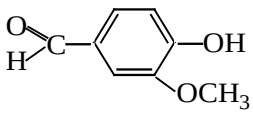
b) 

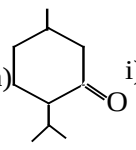
c) 

d) 

e) 

f) 

g) 

h) 

i) CH_3-CH=CH-C(=O)H

2. Write the structural formula for each of the following compounds:

a) Trichloroethanal; b) 2,3,4,5,6-pentahydroxyhexanal;

c) 2-methylcyclohexanone; d) Butandione-2,3;

e) 1,2-diphenylethandione; f) 3-bromo-2-isopropylpentanedial;

g) 3-methylcyclopentanone; h) 2,5-octanedione.

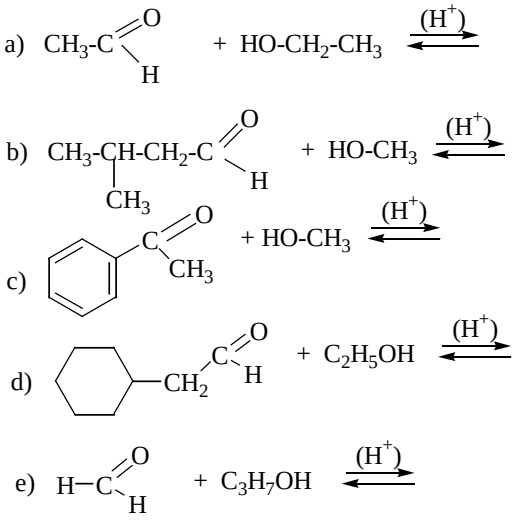
3. Write the structure of hemiacetal and acetal formed by the acid-catalyzed reaction and outline mechanisms for reactions of each of the following aldehydes or ketones with ethanol:

a) propanal;

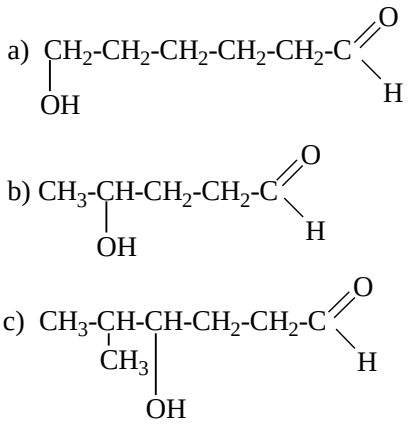
b) ethyl methyl ketone;

c) benzaldehyde.

4. Write schemes and outline mechanisms of the following reactions:



5. Write schemes and mechanisms of cyclic hemiacetals formation from following compounds:

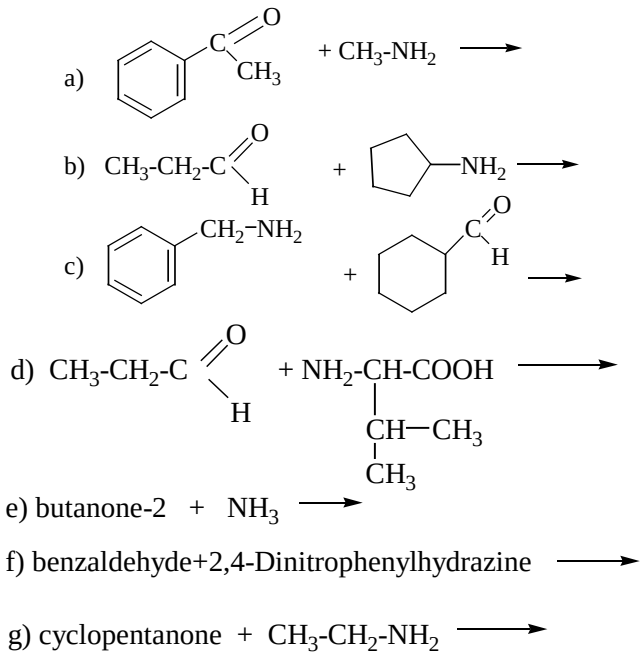


6. Write mechanism of acid-catalyzed hydrolysis of the following compounds:

a) 1,1-diethoxypropane;

b) 1,1-dimethoxyethane.

7. Write the structure of the product and outline the mechanism of each of the following reactions:



8. For all practical purposes, the compound 2,4-cyclohexadien-1-one exists totally in its enol form. Write the structure of 2,4-cyclohexadien-1-one and its enol form. What the special factor accounts for the stability of the enol form?

9. Which of the following compounds would give a positive iodoform test?

a) acetone;
b) pentanal;
c) 2-pentanone;
d) 3-pentanone;
e) 1-phenylethanol;
f) 2-butanol.

10. Write the mechanism for an aldol condensation (aldol-type addition) of the following compounds in base:

a) propanal;
b) 3-methylbutanal;
c) acetone.

3. Laboratory work:

Experiment № 1. Reactions of difference aldehydes from ketones.

Copper mirror reaction.

Sequence of operations: Place 6 drops of NaOH and 1 drop of $CuSO_4$ solutions in two test-tubes.

Check the result: blue precipitate.

Add 2 drops of formalin in the test-tube № 1 and 2 drops of acetone in the test-tube № 2. Warm test-tubes.

Check the result: brick-red precipitate and copper coating in the test-tube № 1 and black precipitate in the test-tube № 2.

Write:

$$CuSO_4 + 2NaOH \longrightarrow Cu(OH)_2\downarrow + Na_2SO_4$$

$$H\text{-}C(=O)H + 2Cu(OH)_2\downarrow \xrightarrow{t^o} H\text{-}C(=O)OH + Cu_2O\downarrow + 2H_2O$$

formaldehyde — methanoic acid — cuprous oxide

$$H\text{-}C(=O)H + Cu_2O \xrightarrow{t^o} H\text{-}C(=O)OH + 2Cu\downarrow$$

formaldehyde — methanoic acid

Explain the result and write conclusion.

Experiment № 2. Formaldehyde disproportionation in water solutions.
Sequence of operations: Place 3 drops of formalin in the test-tube. Add 1 drop of methyl orange (indicator).

Check the result: the change of colour.

Write:

$$2\ H\text{-}C(=O)H + HOH \longrightarrow CH_3OH + H\text{-}C(=O)OH$$

formaldehyde — methanol — methanoic acid

Explain the result and write conclusion.

Experiment № 3. Iodoform test.
Sequence of operations: Place 1 drop of I_2 (in KI solution) in the test-tube. Add 3 drops of NaOH solution and 1 drop of acetone.

Check the result: white-yellow precipitate.

Write:

$$I_2 + 2NaOH \longrightarrow NaI + NaOI + H_2O$$

$$CH_3\text{-}C(=O)\text{-}CH_3 + 3NaOI \xrightarrow[-3NaOH]{} CH_3\text{-}C(=O)\text{-}CI_3 + NaOH \longrightarrow CH_3\text{-}C(=O)O^-Na^+ + CHI_3\downarrow$$

acetone — iodoform

Explain the result and write conclusion.

Experiment №4. Reaction of acetone with sodium nitroprussiate.
Sequence of operations: Place 1 drop of sodium nitroprussiate solution ($Na_2[Fe(CN)_5NO]$, 5 drops of water and 1 drop of acetone in the test-tube. Add 1 drop of NaOH solution.

Check the result: the change of colour.

Pour the part of the mixture in the other test-tube. Add 1 drop of CH_3COOH in one of the test-tubes.

Check the result: the change of colour.

Explain the result and write conclusion.

THEME 8
Carboxylic acids and derivatives.
S_N reactions.

1. Program questions:

1. Nomenclature of carboxylic acids and derivatives (esters, anhydrides, acyl chlorides, amides, nitriles).
2. Reaction centres of carboxylic acids and derivatives.
3. Acidity of carboxylic acids.
4. Nucleophilic substitution (S_N) at the acyl carbon. Forming of esters (esterification), amides, acyl chlorides, anhydrides).
5. Relative reactivity of acyl compounds (acyl chlorides, acid anhydrides, esters, amides).
6. Decarboxylation of carboxylic acids.
7. Hydrolysis of amides and esters.
8. Acyl transfer reactions of anhydrides, thioesters and esters.
9. Acyl transfer reactions in living systems.

Literature:

[1] L.G. Hidranovich. Bioorganic chemistry lecture course. Vitebsk, 2004. p. 136 - 153

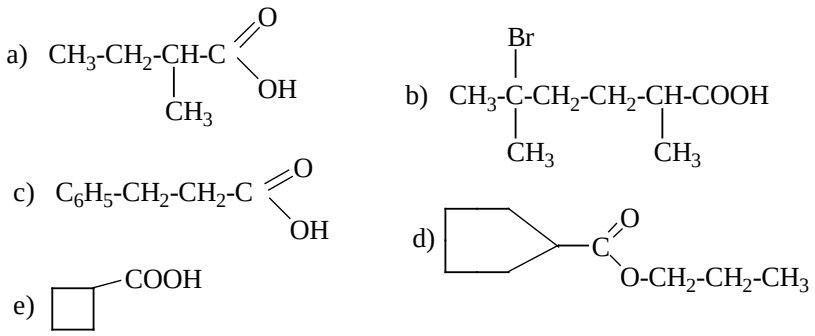
[2] T.W. Graham Solomons. Fundamentals of organic chemistry. John Willey and sons, 1994. p. 714-748, 752-770

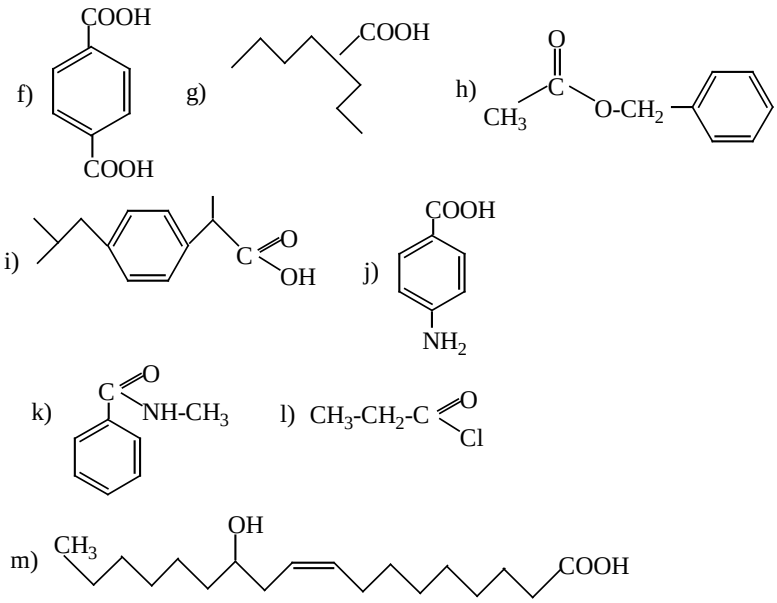
[3] George H. Schmid. Organic chemistry. Mosby, 1996. p. 652-659, 665-673, 697-706, 709-713, 718-726

[4] Richard F. Daley, Sally J. Dalley. Organic chemistry Wm. C. Brown Publishers, 1996. p. 346 – 363, 366 - 368

2. Problems.

1. Give systematic IUPAC names for each of the following:

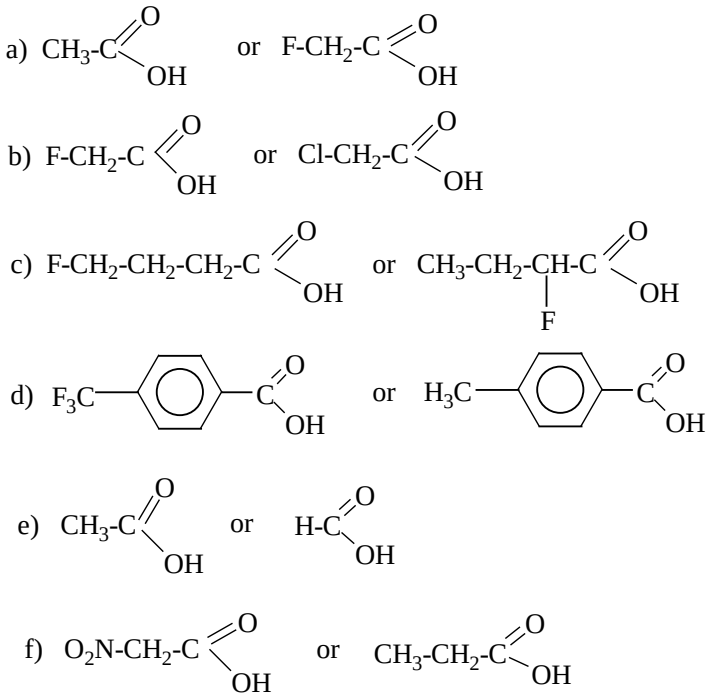




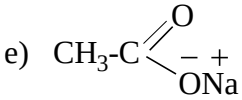
2. Write the structural formula for each of the following compounds:

a) hexanedioic acid;
b) N,N-diethylhexanamide;
c) tert-butyl propanoate;
d) hexadiene-2,4-oic acid;
e) 2-hydroxybenzoic acid;
f) 3-hydroxy-3-carboxypentanedioic acid;
g) trans-butenedioic acid;
h) hexen-4-oic acid;
i) propanoyl chloride;
j) 2-bromopropanoyl bromide;
k) N,N-Dimethylformamide.

3. Which acid of each pair shown here would you expect to be stronger?



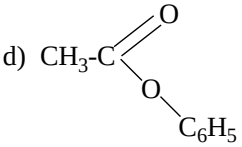
4. What major organic product would you expect to obtain when acetyl chloride reacts with each of the following compounds? Outline mechanisms of these reactions.

a) H_2O;
b) CH_3NH_2 (excess);
c) $(CH_3)_2NH$ (excess);
d) C_2H_5OH;
e) 
f) phenol

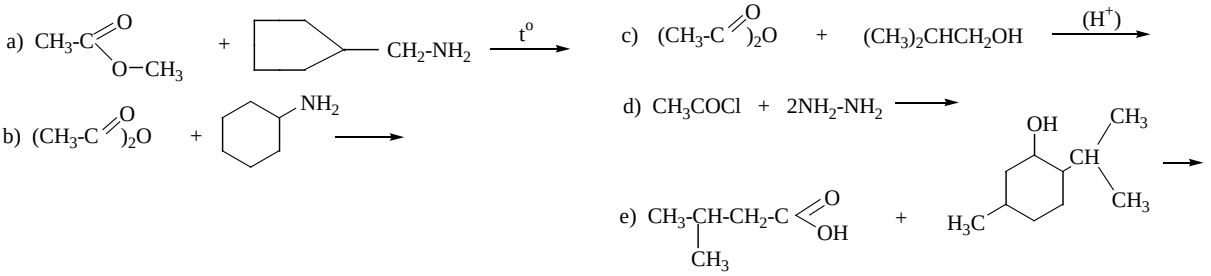
5. What major organic product would you expect to obtain when acetic anhydride reacts with each of the following compounds? Outline mechanisms of these reactions.

a) NH_3 (excess); c) CH_3-CH_2-CH_2-OH;
b) H_2O; d) C_6H_5-NH_2 (excess).

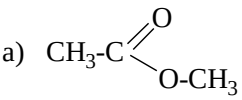
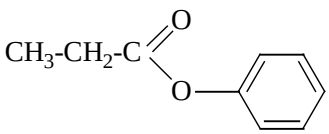
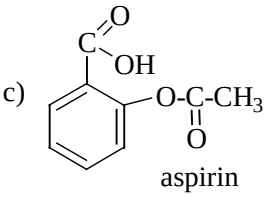
6. Write the scheme and mechanism of the esterification reaction for the synthesis of the following esters:

a) ethyl benzoate;
b) methyl methanoate;
c) methyl cyclopentanecarboxylate;
d) 

7. Predict the products and write mechanisms of each of the following reactions:

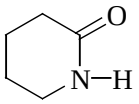


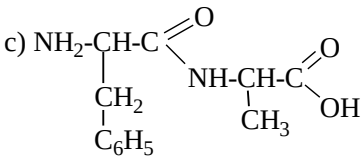
8. Write the mechanism for the acidic and basic hydrolysis of the following compounds:

a) 
b) 
c) 
aspirin

9. What products would you obtain from acidic and basic hydrolysis of each of the following amides?

a) N,N-Diethylbenzamide;

b) 

c) 

10. Acid catalyzed hydrolysis of an ester of molecular formula $C_8H_{16}O_2$ forms a carboxylic acid, compound A, and an alcohol, compound B. Reaction of compound B with acidic $KMnO_4$ forms compound A. Write a structure of the original ester.

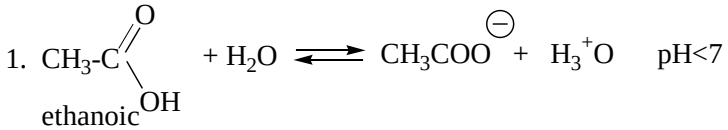
3. Laboratory work:

Experiment № 1. Carboxylic acids dissociation reaction.

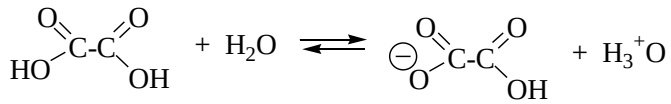
Sequence of operations: Place the small drops of CH_3COOH and HOOC-COOH solutions on the indicator paper.

Check the result: the change of colour and values of pH.

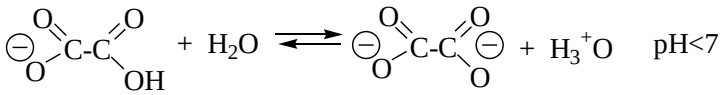
Write:

1. 

ethanoic acid

2. a) 

oxalic acid

b) 

Explain the result and write conclusion.

Experiment № 2. Formation of sodium benzoate.

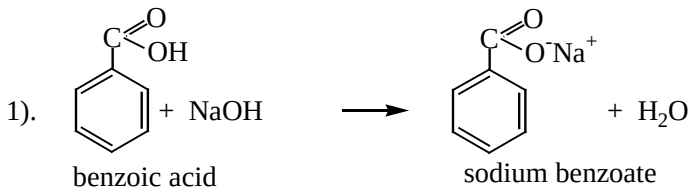
Sequence of operations: Place several crystals of benzoic acid and 2 drops of water in the test-tube. Add 3 drops of NaOH.

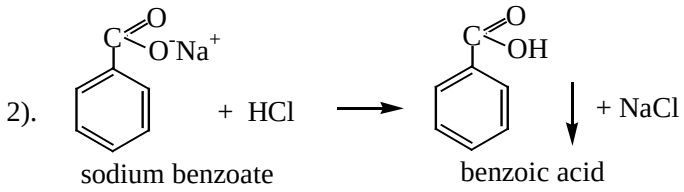
Check the result: the solution.

Add 3 drops of HCl.

Check the result: the precipitate.

Write:





Explain the result and write conclusion.

Experiment № 3. Formation of ethyl acetate.

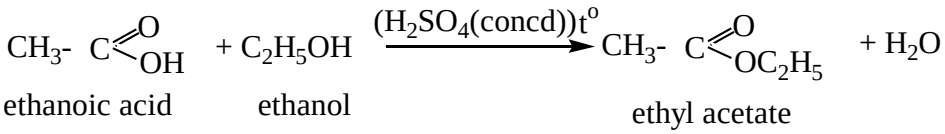
Sequence of operations: Place some sodium acetate in the test-tube (to make the 2 mm high layer). Add 3 drops of C_2H_5OH and 2 drops of concentrated H_2SO_4. Warm the test-tube (Take care!).

Check the result: the specific ethyl acetate smell (see accident prevention 2).

Write:

$$2CH_3COONa + H_2SO_4 \longrightarrow 2CH_3COOH + Na_2SO_4$$

sodium acetate — ethanoic acid



Explain the result and write conclusion.

Experiment № 4. Discover of oxalic acid.

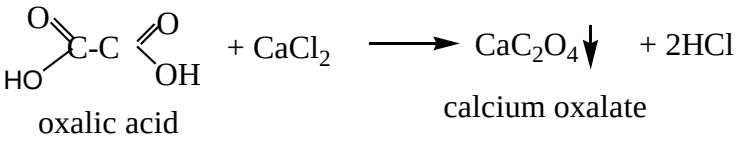
Sequence of operations: Place some oxalic acid and 3 drops of H_2O in the test-tube. Add 2 drops of $CaCl_2$ solution.

Check the result: white precipitate.

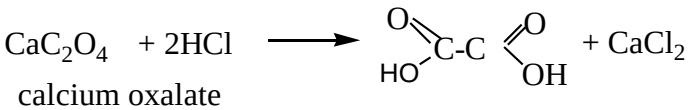
Pour the part of mixture in to other test-tube. Add 3 drops of CH_3COOH in the test-tube № 1 and 3 drops of HCl in the test-tube № 2.

Check the result: the precipitate in the test-tube № 1 and solution in the test-tube № 2.

Write:



oxalic acid — calcium oxalate



calcium oxalate — oxalic acid

Explain the result and write conclusion.

Experiment № 5. Decarboxylation of oxalic acid.

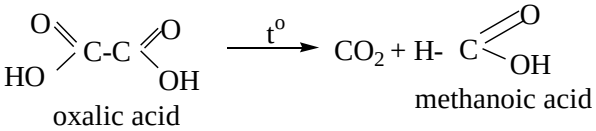
Sequence of operations: Place some oxalic acid in the first test-tube. Close the test-tube with the cork having the glass pipe. Lower the end of the glass pipe in the second test-tube with 3 drops of barium hydrate solution ($Ba(OH)_2$) in it. Warm the first test-tube.

Check the result: the precipitate in the second test-tube.

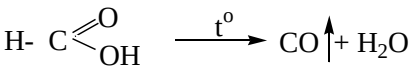
Take out the glass pipe from the second test-tube. To convince that CO is forming, set it on fire near the aperture of the glass pipe.

Check the result: blue flame.

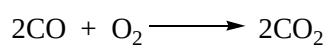
Write:

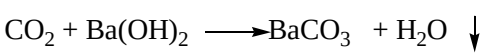


oxalic acid — methanoic acid



methanoic acid





Explain the result and write conclusion.

THEME 9
Poly- and heterofunctionality as one of characteristic signs of organic compounds.

1. Program questions:

1. Polyfunctional compounds reactivity features.

2. Classification of heterofunctional compounds. Aminoalcohols: colamine, choline, adrenaline, noradrenaline. There biological role.

3. Hydroxy and aminoacids. Monocarboxylic (lactic), dicarboxylic (2-hydroxybutanedioic acid, tartaric acid), tricarboxylic (citric) acids. Typical and specific chemical properties of α, β, γ hydroxy and aminoacids.

4. Oxo acids (aldehyde and keto acids). Glyoxyl, pyruvic, acetoacetic, 2-oxobutanoic, α-oxoglutaric acids. Keto-enol tautomerism. Decarboxylating reactions of β-oxo acids.

5. Heterofunctional benzene derivates as pharmaceutical substances. Para-aminobenzoic acid and its derivates. Anesthesine, novocaine).

6. Sulfanilic acid and its derivates. Sulfanilamides. Streptocid.

7. Salicylic acid and its derivates. Sodium salicylate, methyl salicylate, phenyl salicylate, acetylsalicylic acid (aspirine).

Literature:

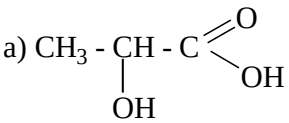
[1] L.G. Hidranovich. Bioorganic chemistry lecture course. Vitebsk, 2004. p. 154 - 170

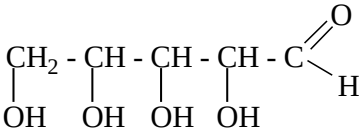
[2] T.W. Graham Solomons. Fundamentals of organic chemistry. John Willey and sons, 1994. p. 805 – 809, 827 – 837, 869 - 870

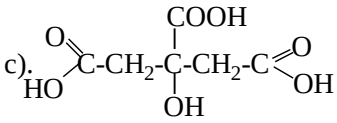
[3] George H. Schmid. Organic chemistry. Mosby, 1996. p. 922, 995 – 997, 1046 - 1063

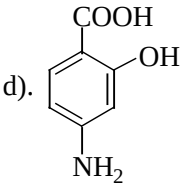
2. Problems.

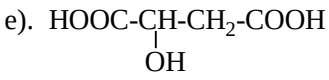
1. Give systematic IUPAC names for each of the following compounds:

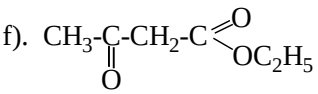
a) 

b) 

c). 

d). 

e). 

f). 

2. Write the structural formula for each of the following compounds:

a) 2-amino-3-(4-hydroxyphenyl)-propanoic acid;
b) N-butyl propanamide;
c) N-4-ethoxyphenyl ethanamide;
d) trans-2-nitrocyclohexanecarboxylic acid;
e) 4-aminobenzenesulfonic acid;
f) pentanepentaol-1,2,3,4,5.

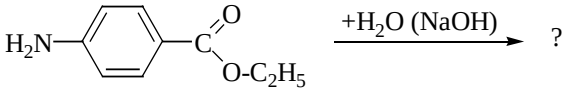
3. Show the reaction centres of 2-aminoethanol. Compare nucleophilic properties of amino and hydroxyl groups. Outline the synthesis of choline by the methylation reaction of 2-aminoethanol.

4. Show the reaction centres of lactic acid (2-hydroxypropanoic acid). Compare the strength of its OH acidic centres and electrophilic centres. Write the scheme of reaction of lactic acid with NaOH and outline mechanism for acid-catalyzed esterification reaction of lactic acid with C_2H_5OH.

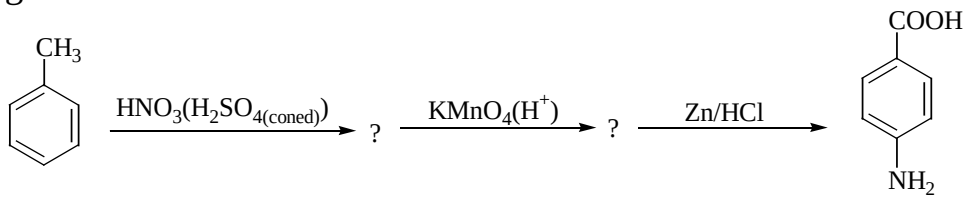
5. Show the reaction centres of 2-oxopropanoic acid. Write the scheme and outline mechanism of the acid-catalyzed esterification reaction of 2-oxopropanoic acid with C_2H_5OH.

6. Write the scheme and mechanism of acid-catalyzed hydrolysis of acetylcholine in living systems.

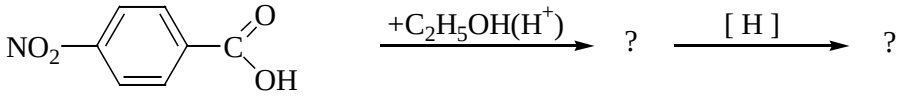
7. The base-catalyzed hydrolysis reaction is used for identification of anesthesine. Write the scheme and outline the mechanism of this reaction.



8. 4-Aminobenzoic acid is prepared from toluene. Write the scheme of preparing 4-aminobenzoic acid from toluene.



9. Esters of 4-aminobenzoic acid are used as anesthetics. They are prepared from 4-nitrobenzoic acid. Write the schemes of reactions.



10. a) Write tautomeric forms of acetoacetic ester and outline schemes of reactions that prove existence of two tautomeric forms.

b) What tautomeric form do you expect to be a stronger acid? Write scheme of reaction that proves acidic properties of acetoacetic ester.

11. Write the scheme of the decarboxylation reaction of acetoacetic acid. Name the product of this reaction.

12. What products do you expect to get after the heating of 2-aminobutanedioic acid.

3. Laboratory work:

Experiment № 1. Reactions of lactic acid.

A. Discovery of formic acid.

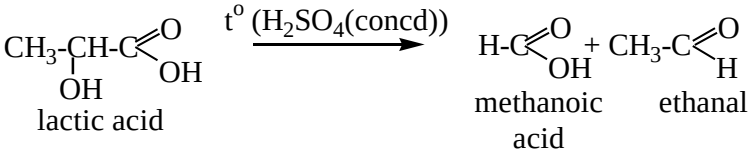
Sequence of operations: Place 1 drop of lactic acid and 1 drop of concentrated H_2SO_4 (Take care!) Warm the mixture.

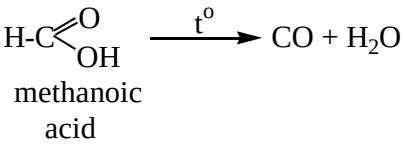
Check the result: black foam.

To convince that CO is forming, set it on fire near the aperture of the test-tube.

Check the result: the blue flame.

Write:





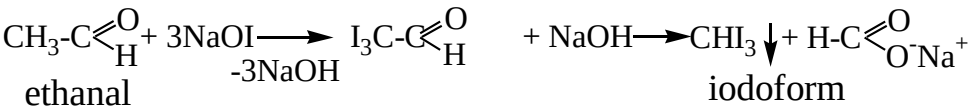
B. Discovery of ethanal.

Sequence of operations: Place 2 drops of H_2O, 1 drop of concentrated H_2SO_4 and 1 drop of lactic acid in the test-tube № 1.

Close it with the cork with the glass pipe. Lower the end of the glass pipe in the test-tube № 2 with 1 drop of I_2 (in KI solution) and 2 drops of NaOH in it. Warm the test-tube №1.

Check the result: white-yellow precipitate in the test-tube № 2.

Write:



Explain the result and write conclusion.

Experiment № 2. Tartaric acid has 2 carboxy groups.

Sequence of operations: Place 1 drop of tartaric acid solution in the test-tube. Add 2 drops of KOH. Shake the test-tube.

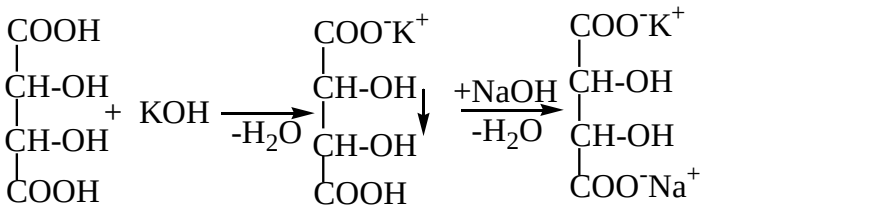
Check the result: white precipitate.

Add some more drops of NaOH.

Check the result: the solution.

<u>Attention:</u> you need this solution for the next experiment.

Write:



Explain the result and write conclusion.

Experiment № 3. Tartaric acid has 2 hydroxyl groups.

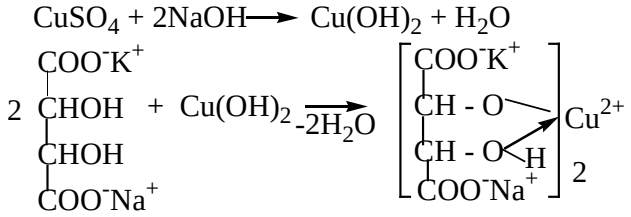
Sequence of operations: Place 2 drops of $CuSO_4$ in the test-tube. Add 2 drops of NaOH.

Check the result: blue precipitate.

Add the potassium sodium tartrate (you received it in the experiment № 2).

Check the result: blue solution (it is named Fehling's solution).

Write:



potassium sodium tartrate

Explain the result and write conclusion.

Experiment № 4. Discovering two tautomeric forms of acetoacetic ester.

Sequence of operations: Place 1 drop of acetoacetic ester and 1 drop of $FeCl_3$ solution.

Check the result: violet-red solution.

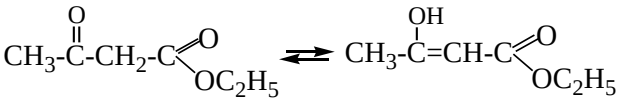
Add 1 drop of bromine water.

Check the result: violet colour disappeas, but it appeas again in several seconds.

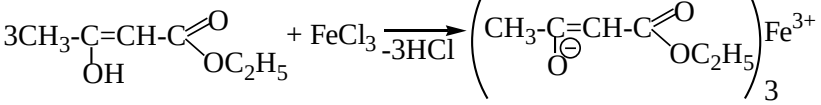
Add one more drop of bromine water.

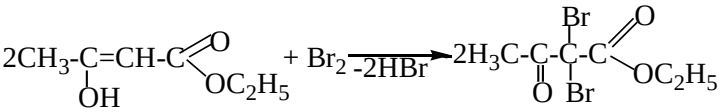
Check the result: the same change.

Write:



acetoacetic ester





Explain the result and write conclusion.

Experiment № 5. Hydrolysis of acetylsalicylic acid.

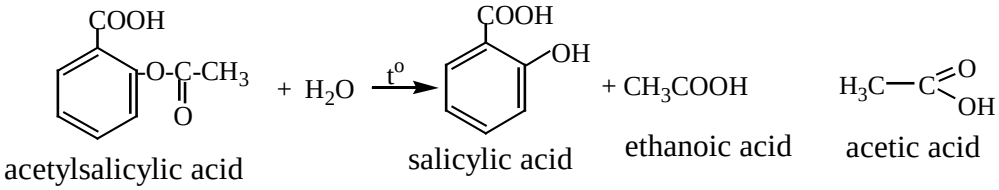
Sequence of operations: Place some acetylsalicylic acid and 6 drops of H_2O in the test-tube №1. Shake the test-tube. Pour the part of the mixture in the test-tube № 2. Add 1 drop of $FeCl_3$ solution in the test-tube № 2.

Check the result: violet colour is not appearing.

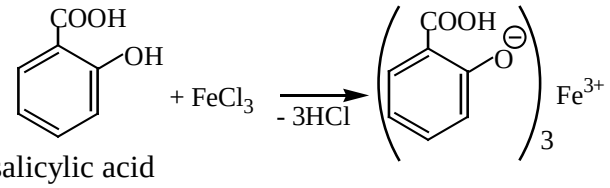
Warm the test-tube № 1 during 30 seconds. Add 1 drop of $FeCl_3$ solution.

Check the result: violet colour.

Write:



acetylsalicylic acid — salicylic acid — ethanoic acid — acetic acid



salicylic acid

Explain the result and write conclusion.

THEME 10
TEST № 1
Theoretical foundations of structure and reactivity of main families of organic compounds

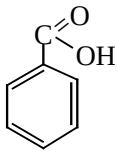
I. Program questions for theoretical part of test № 1:

1. Remind yourself the program material from the theme № 1 to № 9.

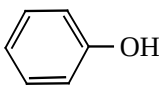
Literature:

Study the literature from the themes № 1 - № 9.

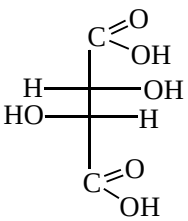
2. The list of compounds for qualitative functional analysis (student educational-investigative work):



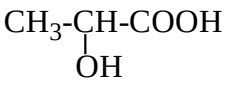
Benzoic acid



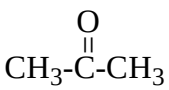
Phenol



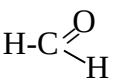
(+)-tartaric acid



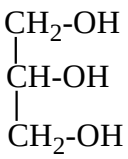
Lactic acid



Acetone



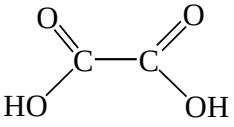
Formaldehyde



Glycerol

cyclohexene

ethanol



oxalic acid

Requirements for the answer:

1. Write the structural formulas of both organic compounds (given in the task).
2. Classify both organic compounds according to the functional groups families and principles of classification as bioorganic compounds.
3. Write physical properties of organic compounds: solid or liquid colour, solubitity in water.
4. Write the schemes of qualitative reactions for both organic compounds given in the task. Indicate the results (precipitate, change of the colour and so on).
5. Make the qualitative tests according to the sequence of operations.
6. Write the answer of experimental task (on the base of explanation of the experiment results).

THEME 11
Carbohydrates. Monosaccharides.

1. Program questions:

1. Classification of carbohydrates. Monosaccharides. Structural formulas of the main pentoses (D-ribose, D-xylose, D-ribulose, D-xylulose) and hexoses (D-glukose, D-mannose, D-galactose, D-fructose).

2. Stereochemistry of monosaccharides. D and L designation of monosaccharides. Fischer projection formulas. Diastereomers, enantiomers, epimers.

3. Open-chain forms and cyclic forms of monosaccharides. Haworth formulas: (pyranose and furanose rings). Anomers.

4. Conformations of monosaccharides. Most stable conformations of hexoses.

5. Reactions of monosaccharides: glycoside formation (O- and N-glycosides). Hydrolysis of glycosides.

6. Formation of ethers. Conversion to esters.

7. Reactions of oxo-group. Oxidation reactions of monosaccharides. Benedict's and Tollen's reagents. Reducing sugars.

8. The synthesis of aldonic acids (oxidation by bromine water). The synthesis of aldaric acids (nitric acid oxidation). Uronic acids. Reduction of monosaccharides: alditols.

9. Deoxy sugars. Amino sugars.

Literature:

[1] L.G. Hidranovich. Bioorganic chemistry lecture course. Vitebsk, 2004. p. 170 - 186

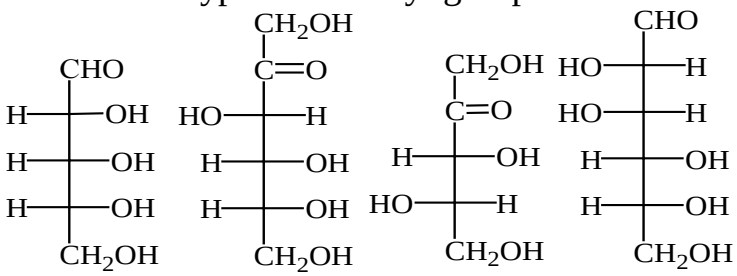
[2] T.W. Graham Solomons. Fundamentals of organic chemistry. John Willey and sons, 1994. p. 891 - 920

[3] George H. Schmid. Organic chemistry. Mosby, 1996. p. 1092 – 1098, 1101 - 1118

[4] Richard F. Daley, Sally J. Dalley. Organic chemistry Wm. C. Brown Publishers, 1996. p. 1227 – 1237, 1240 - 1245

2. Problems.

1. Classify each of the following monosaccharides according to the number of carbon atoms and the type of carbonyl group it contains.



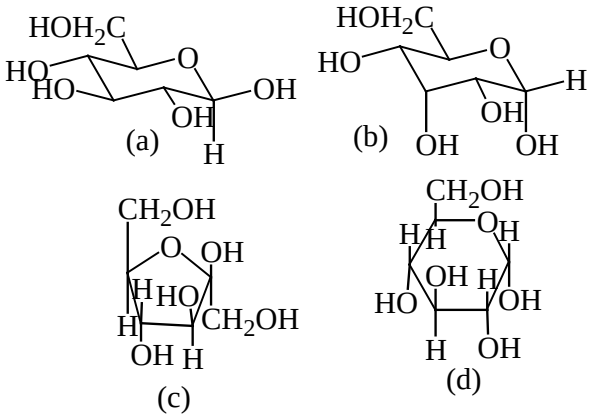
(a) (b) (c) (d)

3. Label the stereocenters in each of the monosaccharides in Exercise 1 by an asterisk and determine the maximum number of stereoisomers of each. Assign each of the monosaccharides in Exercise 1 to either the D- or L-family.

4. Write the cyclic forms for each of the monosaccharides in Exercise 1. Indicate which is the α-anomer and which is the β-anomer. Draw conformational formulas for each of the pyranose forms.

5. Write a chair representation of the pyranose form of each of the following monosaccharides in Exrcise 1.

6. Write the Fisher projection formula for each of the following cyclic monosaccharides

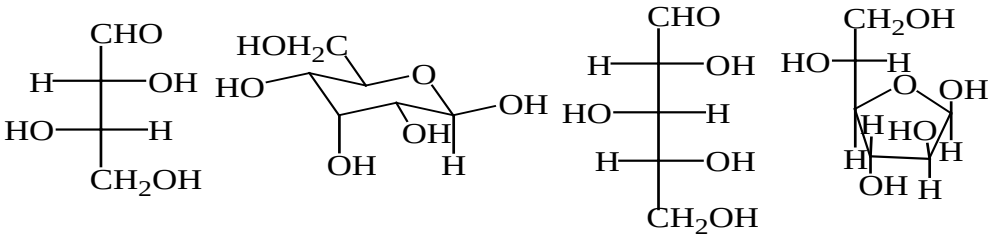


7. Write the structure of products, if any, of the reaction of α-D-galactopyranose with each of the following reagents.

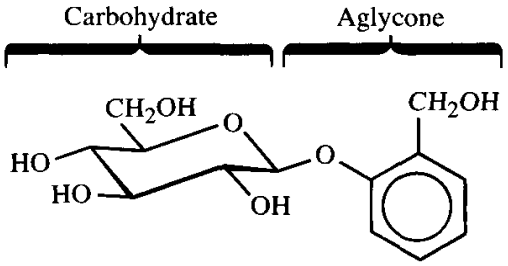
(a) CH_3OH/HCl; (b) $(CH_3O)_2SO_2/NaOH$; (c)$(RCO)_2O/CH_3COONa$

(d) Fehling's solution; (e) Br_2/H_2O; (f) HNO_3

8. Write the structure of the aldonic acids and aldaric acids obtained by oxidation of each of the following monosaccharides. Write the structure of alditols obtained by reduction of each of the following monosaccharides:



9. Write the reaction of the acid-catalyzed hydrolysis of methyl α-D-glucopyranoside and pentamethyl derivative.
10. Write the reaction of the acid-catalyzed and base-catalyzed hydrolysis of esters of β-D-mannopyranose.
11. Salicin is naturally occurring compound, find in the bark of willow trees.



Salicin

Salicin can be converted to salicylic acid which, in turn, can be converted into the most widely used modern analgetic, aspirin. Write the scheme of this reaction, show the condition, name the products.

3. Laboratory work.

Experiment № 1. Glucose has hydroxyl groups.

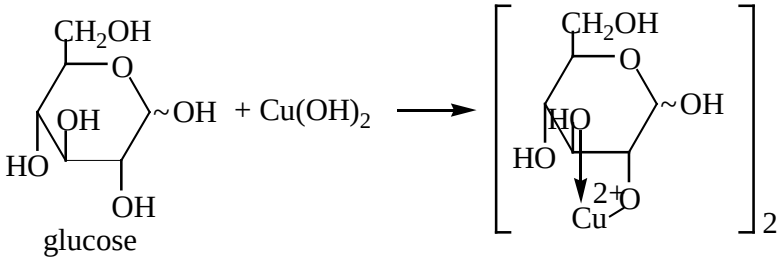
Sequence of operations: Place 1 drop of glucose solution in the test-tube. Add 6 drops of NaOH and 1 drop of $CuSO_4$.

Check the result: blue solution.

Attention: you need this solution for the next experiment.

Write:

$$CuSO_4 + 2NaOH \rightarrow Cu(OH)_2\downarrow + Na_2SO_4$$



glucose

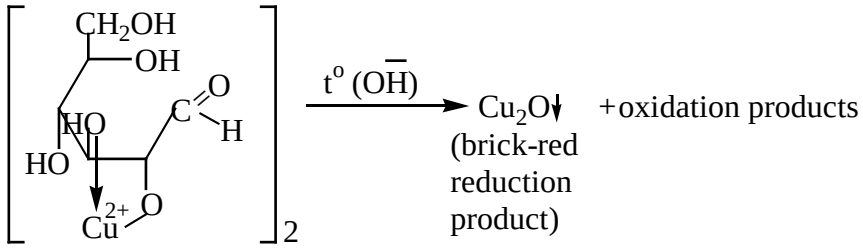
Explain the result and write conclusion.

Experiment № 2. Oxidation of glucose by $Cu(OH)_2$.

Sequence of operations: Take the solution you received in the experiment № 1. Add 8 drops of H_2O. Warm the test-tube.

Check the result: brick-red precipitate.

Write:



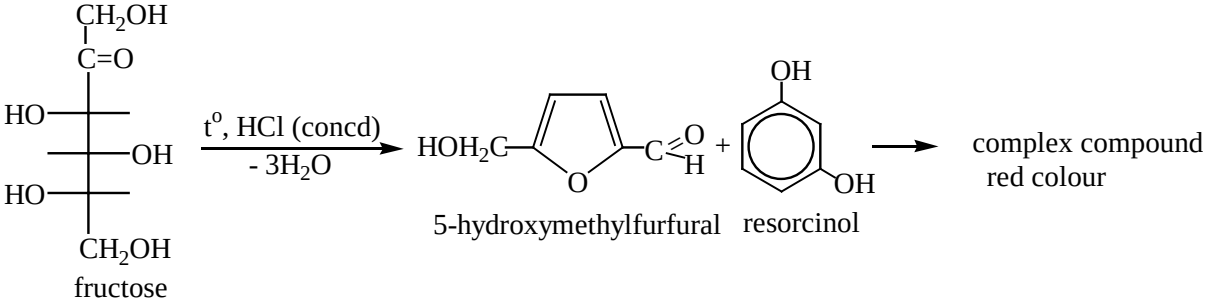
Explain the result and write conclusion.

Experiment № 3. Reaction of fructose with resorcinol.

Sequence of operations: Place 1 crystal of resorcinol and 2 drops of concentrated HCl (Take care!) in the test-tube. Add 2 drops of fructose solution. Warm the test-tube.

Check the result: the change of colour.

Write:



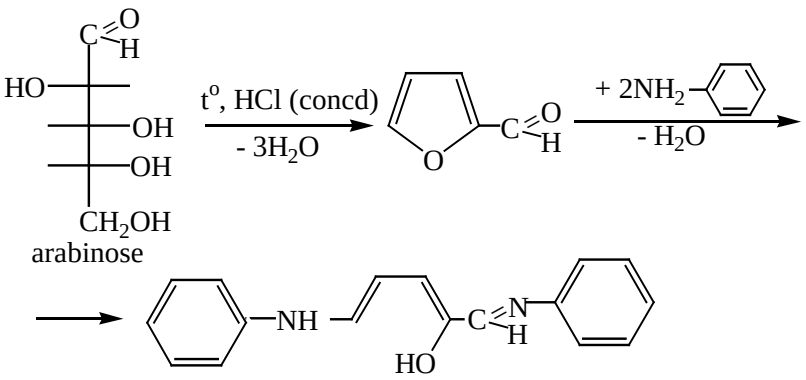
Explain the result and write conclusion.

Experiment № 4. Qualitative test for pentoses.

Sequence of operations: Place some arabinose in the test-tube № 1. Make the mixture of 3 drops of concentrated HCl (Take care!) and 3 drops of H_2O in the test-tube № 2. Add this mixture in the test-tube № 1. Place 1 drop of aniline and 1 drop of CH_3COOH on the filter paper. Place this filter paper on the inner border of the test-tube № 1.Warm the test-tube.

Check the result: the filter paper becomes red coloured.

Write:



Explain the result and write conclusion.

THEME 12
Carbohydrates. Oligosaccharides and polysaccharides.

1. Program questions:

1. Classification of polysaccharides.

2. Oligosaccharides. Disaccharides: maltose, cellobiose, lactose, sucrose. Structure, tautomerism. Reducing properties. Hydrolysis. Conformations of maltose and cellobiose.

3. Typical and special reactions of reducing and nonreducing disaccharides.

4. Homopolysaccharides. Starch (amylose and amylopectin), glycogen, cellulose. Primary structure, hydrolysis, secondary structure (amylose, cellulose).

5. Heteropolysaccharides. Hyaluronic acid, chondroitin sulfates, heparin. Primary structure. Biologycal role.

6. Glycolipids and glycoproteins.

Literature:

[1] L.G. Hidranovich. Bioorganic chemistry lecture course. Vitebsk, 2004. p. 187 - 204

[2] T.W. Graham Solomons. Fundamentals of organic chemistry. John Willey and sons, 1994. p. 920 - 934

[3] George H. Schmid. Organic chemistry. Mosby, 1996. p. 1118 – 1130

[4] Richard F. Daley, Sally J. Dalley. Organic chemistry Wm. C. Brown Publishers, 1996. p. 1268 - 1271

2. Problems.

1. Write the structure of the product of the reaction of β-maltose with each of the following reagents:

a) HOH/H^+ c) Tollen's reagent

b) Br_2/HOH d) $(CH_3O)_2SO_2/NaOH$

2. Write the structure of the product of the reaction of α-cellobiose with each of the following reagents:

a) HOH/H^+ c) $(CH_3CO)_2O/CH_3COO^-Na^+$

b) Br_2/H_2O d) $NaBH_4$ e) Fehling's solution

3. Direct oxidation of an aldose affects the aldehyde group first, converting in to a carboxylic acid, and most oxidazing agents that will attack 2^o alcohol groups. Cleary, then, a laboratory synthesis of a uronic acid from an aldose requires protecting these groups from oxidation. Keeping this in mind, suggest a method for carrying out a specific oxidation that would convert D-galactose to D-galacturonic acid.

4. Show how the following experimental evidence can be used to deduce the structure of lactose.

a) Acid hydrolysis of lactose ($C_{12}H_{22}O_{11}$) gives equimolar quantities of D-glucose and D-galactose. Lactose undergoes a similar hydrolysis in the presence of a *β-galactosidase,*

b) Lactose is a reducing sugar.

c) Oxidation of lactose with bromine water followed by hydrolysis with dilute acid gives D-galactose and D-gluconic acid.

d) Bromine water oxidation of lactose followed by methylation and hydrolysis gives 2,3,6-tri-0-methylgluconolactone and 2,3,4,6-tetra-O-methyl-D-galactose.

e) Methylation and hydrolysis of lactose gives 2,3,6-tri-O-methyl-D-glucose and 2,3,4,6-tetra-O-methyl-D-galactose.

5. Deduce the structure of the disaccharide melibiose from the following data:

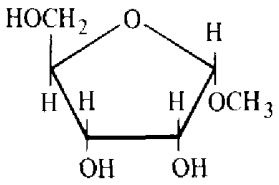
a) Melibiose is a reducing sugar.
b) Hydrolysis of melibiose with acid or with an *α-galactosidase* gives D-galactose and D-glucose.
c) Bromine water oxidation of melibiose gives *melibionic acid.* Hydrolysis of melibionic acid gives D-galactose and D-gluconic acid. Methylation of melibionic acid followed by hydrolysis gives 2,3,4,6-tetra-O-methyl-D-galactose and 2,3,4,5-tetra-O-methyl-D-gluconic acid.
d) Methylation and hydrolysis of melibiose gives 2,3,4,6-tetra-O-methyl-D-galactose and 2,3,4-tri-O-methyl-D-glucose.

6. Trehalose is a disaccharide that can be obtained from yeasts, fungi, sea urchins,algae,and insects. Deduce the structure of trehalose from the following information:

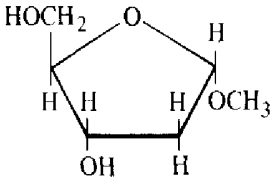
a). Acid hydrolysis of trehalose yields only n-glucose.
b). Trehalose is hydrolyzed by D-glucosidases but not by β-glucosidases.
c). Trehalose is a nonreducing sugar;
d). Methylation of trehalose followed by hydrolysis yields two molar equivalents of 2,3,4,6-tetra-O-methyl-D-glucose.

7. Outline chemical tests that will distinguish between each of the following:

(a) D-Glucose and D-glucitol
(b) D-Glucitol and D-glucaric acid
(c) a-Glucose and D-fructose
(d) D-Glucose and D-galactose
(e) Sucrose and maltose
(f) Maltose and maltonic acid
(g) Methyl β-D-glucopyranoside and 2,3,4,6-tetra-O-methyl-β-D-glucopyranose
(h) Methyl α.-D-ribofuranoside (I) and methyl 2-deoxy-α-D-ribofuranoside (II)



I



II

3. Laboratory work.

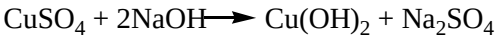
Experiment № 1. Lactose and sucrose have hydroxyl groups.

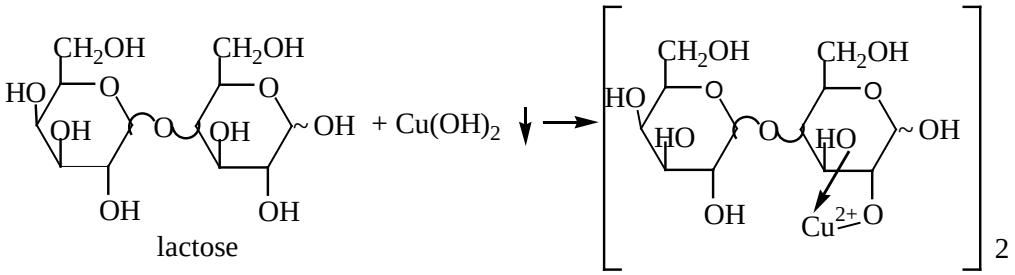
Sequence of operations: Place 1 drop of lactose solution in the test-tube № 1 and 1 drop of sucrose solution in the test-tube № 2. Add 6 drops of NaOH and 1 drop of $CuSO_4$ solutions in two test-tubes.

Check the result: blue solution.

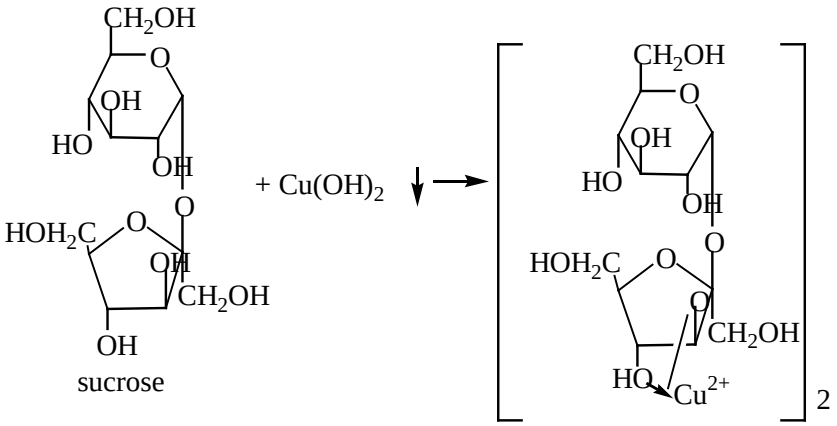
Attention: you need these solutions for the next experiment.

Write:





lactose



sucrose

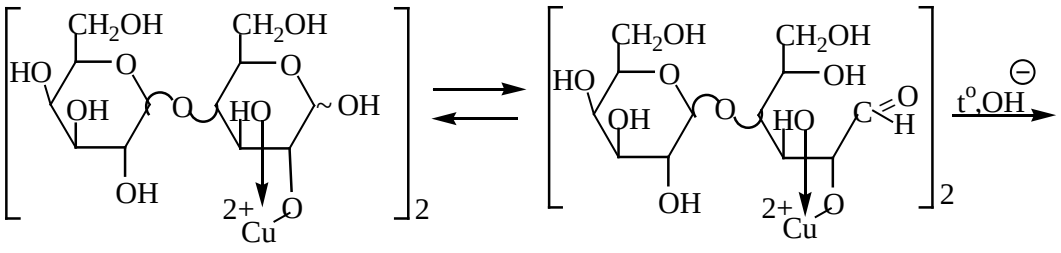
Explain the result and write conclusion.

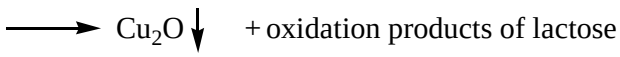
Experiment № 2. Reducing power of lactose and sucrose.

Sequence of operations: Warm the test-tubes with solutions you received in the experiment № 1.

Check the result: brick-red precipitate in the test-tube №1.

Write:





Explain the result and write conclusion.

Experiment № 3. Proof of sucrose hydrolysis.

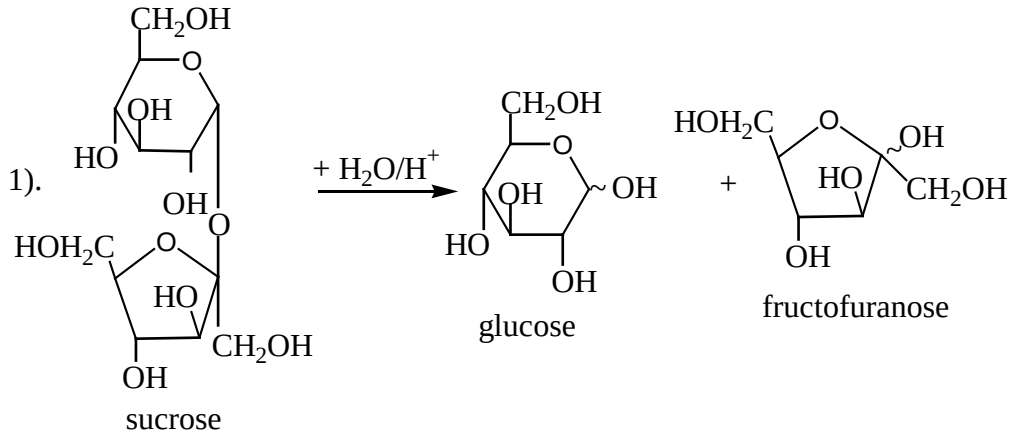
Sequence of operations: Take 2 test-tubes. Place 1 drop of sucrose solution in the test-tube № 1. Add 1 drop of HCl and 6 drops of H_2O. Warm the test-tube № 1 during 0,5-1 minute. Pour half of the solution, received in the test-tube № 1 in the test-tube № 2. Add 6 drops of NaOH, 4 drops of H_2O and 1 drop of $CuSO_4$ in the test-tube № 2. Warm the test-tube № 2.

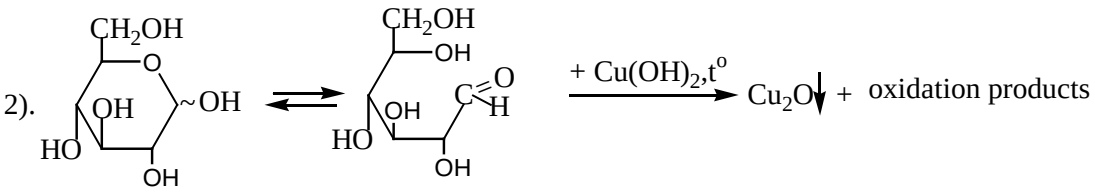
Check the result: brick-red precipitate.

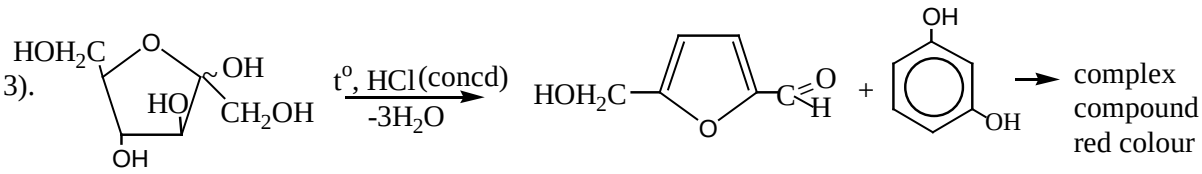
Add 1 crystal of resorcinol and 2 drops of concentrated HCl (Take care!) in the test-tube № 1.

Check the result: the change of colour.

Write:



2). 

3). 

Explain the result and write conclusion.

Experiment № 4. Discovery of the starch.

Sequence of operations: Place 5 drops of the starch paste solution in the test-tube. Add 1 drop of very diluted I_2 solution.

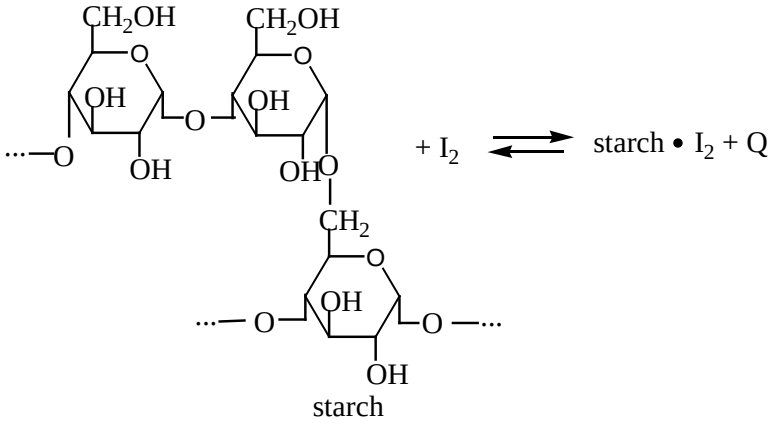
Check the result: blue solution.

Warm the test-tube.

Check the result: colourless solution.

In getting cold the solution become blue again.

Write:



Explain the result and write conclusion.

Experiment № 5. Starch has no reducing power.

Sequence of operations: Place 10 drops of the starch paste in the test-tube. Add 3 drops of NaOH and 1 drop of $CuSO_4$ solution. Shake the test-tube.

Check the result: blue precipitate of $Cu(OH)_2$

Warm the test-tube.

Check the result: black precipitate of CuO.

Write:

$$CuSO_4 + 2NaOH \rightarrow Cu(OH)_2 + Na_2SO_4$$

$$Cu(OH)_2 \xrightarrow{t^o} CuO\downarrow + H_2O$$

Explain the result and write conclusion.

Experiment № 6. Acidic hydrolysis of the starch.

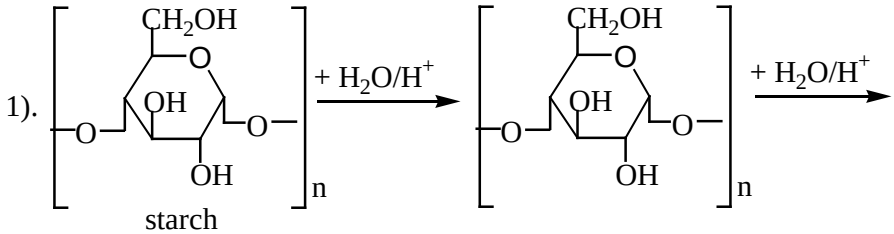
Sequence of operations: Place 1 drop of the starch paste solution in the test-tube. Add 2 drops of H_2SO_4. Warm the test-tube on the water bath during 20 minutes. Place 1 drop of this solution in the glass. Add 1 drop of very diluted I_2 (with KI) solution.

Check the result: solution has no blue colour.

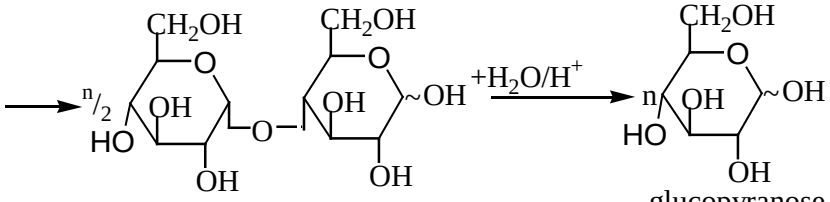
Add 8 drops of NaOH and 1 drop of $CuSO_4$ solutions in the test-tube. Warm the test-tube.

Check the result: brick-red precipitate.

Write:

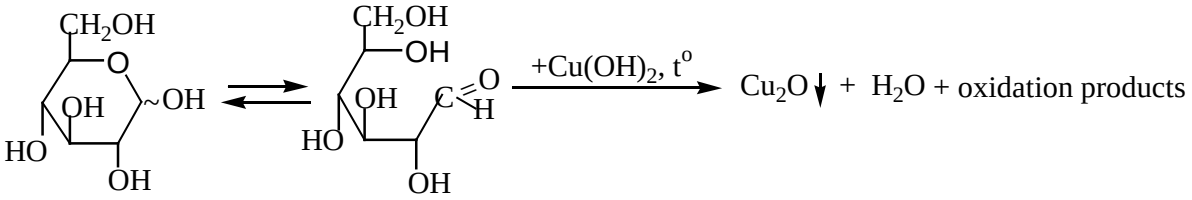
1). 

starch



maltose glucopyranose

2). $CuSO_4 + 2NaOH \rightarrow Cu(OH)_2\downarrow + Na_2SO_4$



Check the result and write conclusion.

THEME 13
Natural amino acids. Structure, properties, functions.

1. Program questions:

1. Classification, structure and stereochemistry of α-amino acids.

2. Reactions of amino acids as heterofunctional compounds. Acid-base properties. Dipolar ions.

3. Reactions of carboxyl group of amino acids. Esterification.

4. Reactions of amino group of amino acids. Reactions with aldehydes and ketones, carboxylic acids and their derivates, nitrous acid (nitrosation).

5. Deamination and enzyme-catalyzed transamination reactions. Pyridoxal phosphate catalysis.

Literature:

[1] L.G. Hidranovich. Bioorganic chemistry lecture course. Vitebsk, 2004. p. 205 - 217

[2] T.W. Graham Solomons. Fundamentals of organic chemistry. John Willey and sons, 1994. p. 972 - 979

[3] George H. Schmid. Organic chemistry. Mosby, 1996. p. 1144 – 1151

[4] Richard F. Daley, Sally J. Dalley. Organic chemistry Wm. C. Brown Publishers, 1996. p. 1166 - 1173

2. Problems.

1. Write Fischer projection formulas for each of the following amino acids:
(a) L-Valine, (b) D-Cysteine (c) L-Glutamine (d) L-Phenylalanine
2. Write the structure of each of the following amino acids in solution at pH=3, pH=8, pH=11
(a) Leu, (b) Met, (c) Asp, (d) Lys
3. Write the structure of the predominant form of each of the following amino acids at the pH of blood 7,4
(a) Ser (b) Glu (c) His (d) Gly
4. Write the structure of the predominant form of threonine in each solution of the following pH:
(a) pH=0,2 (b) pH=9,8 (c) pH=13 (d) pH=5,0
5. Explain why there is a difference of 2,4 units between the pK_a of carboxyl group of alanine (2,3) and the pK_a of acetic acid (4,7).
6. Which of the side chains of the 20 amino acids are charged at pH=7.
7. Write the structure of the product of the reaction of isoleucine with each of the following reagents:
   a. CH_3OH/HCI
   b. Basic aqueous solution of bensoyl chloride
   c. Acetic anhydride
8. Write the structure of the product formed in each of the following reactions:
(a) Asn + NaOH/HOH(Heat) →
(b) Lys + HCI →
(c) Asp + NaOH →
(d) Trp + $NaNO_2$/HCI →
(e) Phe + $H_2C=O$ →
9. Write the structure of the product of each of the following reactions:

(a) 2-oxopropanoic acid + Glutamic acid $\xrightarrow{\text{aminotransferase}}$

(b) 2-oxobutandioic acid + alanine $\xrightarrow{\text{aminotransferase}}$

(c) Histidine $\xrightarrow{\text{decarboxylase}}$

(d) Write the scheme of deamination reaction of Glu.

3. Laboratory work.

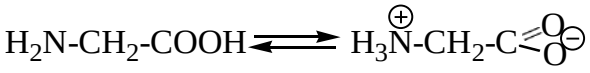
Experiment 1. Glycine solution has neutral pH value.

Sequence of operations: Place 3 drops of glycine solution in the test-tube. Add 1 drop of 0,2% methyl red (indicator) solution.

Check the result: change of colour.

Remember that indicator methyl red colour change zone is at pH 4,4-6,2.

Write:



glycine

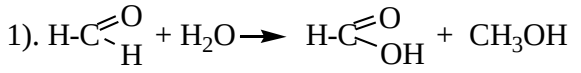
Explain the result and write conclusion.

Experiment 2. Glycine reacts with formaldehyde.

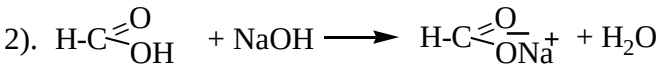
Sequence of operations: Place 3 drops of 40% formadehyde solution in the test-tube. Add 1 drop of 0,2% methyl red (indicator) solution. Note the red colour of solution. Use the thin glass capillary to add only a small amount of 2 M NaOH solution to achieve neutral pH value (the solution will become yellow). Add this solution to glycine solution (obtained in previous experiment).

Check the result: the red colour of solution, that indicated the low pH value of the solution.

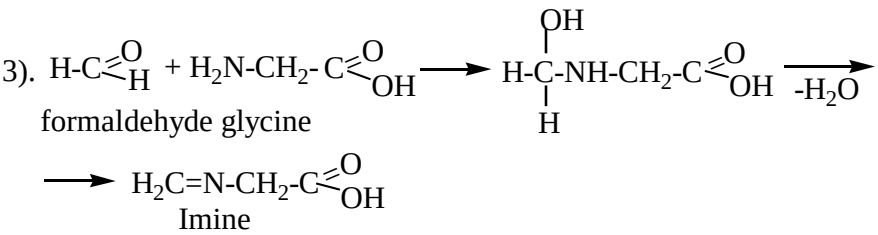
Write:



formaldehyde formic acid methanol



formic acid



formaldehyde glycine

Imine

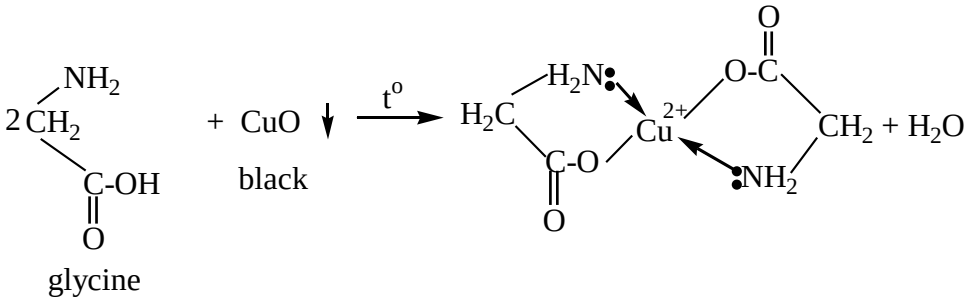
Explain the result (why the solution became acidic?) and write conclusion.

Experiment 3. Formation of copper and glycine complex compound.

Sequense of operations: Place CuO on tip spade in the test-tube. Add 3 drops of 0,2 M glycine solution and warm the test-tube

Check the result: dark-blue copper salt glycine solution.

Write:



Explain the result and write conclusion.

Experiment 4. Glycine reacts with nitrous acid.

Seguence of operations: Place 5 drops of 0,2 M glycine solution in the test-tube. Add 5 drops of 5% sodium nitrite ($NaNO_2$) solution and 2 drops of concentrated acetic acid. Shake mixture carefully.

Check the result: bubbles of gas.

Write:

$$NaNO_2 + CH_3COOH \rightarrow HNO_2 + CH_3COO^-Na^+$$

$$H_2N\text{-}CH_2\text{-}COOH + HNO_2 \rightarrow HO\text{-}CH_2\text{-}COOH + N_2\uparrow + H_2O$$

glycine

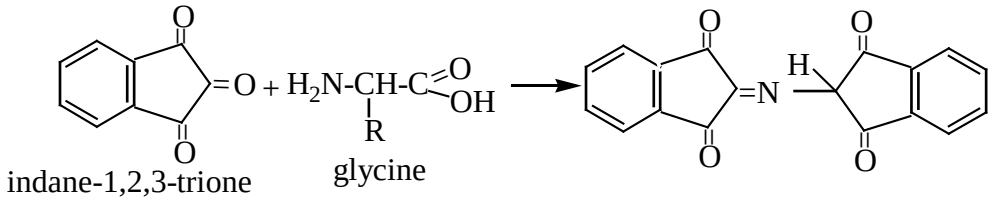
Explain the result and write conclusion.

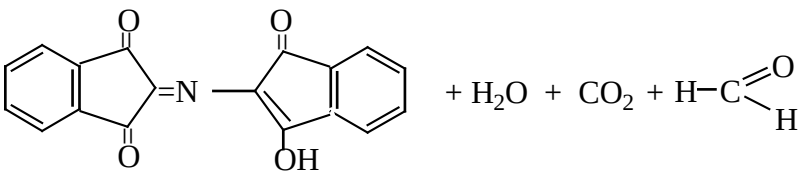
Experiment 5. Glycine reacts with ningidrin.

Sequence of operations: Place 4 drops of 0,2 M glycine solution in the test-tube. Add 2 drops of ningidrin solution. Warm the test-tube carefully.

Check the result: blue-red colour.

Write:





Explain the result and write conclusion.

THEME 14
Peptides and proteins. Four levels of proteins structural organization. Strategy of peptide synthesis.

1. Program questions:

1. Biologycal functions of peptides and proteins.

2. Structure of peptides and proteins. Peptide bond, N -and C-terminal residues.

3. Properties of peptides. Isoelectric point (pI) of peptides. Acidic and basic hydrolysis of peptides.

4. Primary structure of peptides and proteins. Amino acid sequence. Terminal residue analysis. (Sanger method, Edman degradation). Partial hydrolysis.

5. Polypeptide and protein synthesis. Protecting groups. Activation of the carboxyl groups.

6. Secondary structure of proteins. α-Helix and β-sheet (β-configuration).

Tertiary and quaternary structures of proteins.

Literature:

[1] L.G. Hidranovich. Bioorganic chemistry lecture course. Vitebsk, 2004. p. 217 - 237

[2] T.W. Graham Solomons. Fundamentals of organic chemistry. John Willey and sons, 1994. p. 986 - 1005

[3] George H. Schmid. Organic chemistry. Mosby, 1996. p. 1151-1175

[4] Richard F. Daley, Sally J. Dalley. Organic chemistry Wm. C. Brown Publishers, 1996. p. 1176 – 1179, 1181 – 1194, 1197 - 1203

2. Problems.

1. Write the sructure of tripeptide Ala-Met-Glu in solution at:

(a) pH= 1; (b) pH=3; (c) pH=11

2. Aspartame, a widely used nonnutritive sweetener, is the methyl ester of the dipeptide Asp-Phe. Draw the full structure of aspartame. The isoelectric point of aspartame is 5.9. Draw the structure present in aqueous solution at this Ph.

3. Write a reaction showing how 2,4-dinitrofluorobenzene could be used to identify the N-terminal amino acid of Val-Ala-Gly.

4. What products would you expect (after hydrolysis) when Val-Lys-Gly is treated whith 2,4 - dinitrofluorobenzene?

5. Write the reaction involved in a sequential Edman degradation of Met-Ile-Arg.

6. Indicate where $N{\equiv}CBr$, trypsin and chymotrypsin will cleave the following polypeptide chain:

Ala-Val-Lyz-Met-Ile-Pro-Tyr-Thr-Arg-Ser-Met-Leu-His-Gln.

7. The following peptide was subjected to:

1) Edman degradation;

2) trypsin hydrolysis;
3) chymotrypsin hydrolysis.

What result would you find from each of these three experiments:

H_2N-Glu-Lys-Phe-Cys-Val-Tyr-Met-Ala-Phe-COOH.

8. Give the amino acid sequence of following polypeptides using only the data given by partial acidic hydrolysis

(a) Ser, Hys, Pro, Thr → Ser-Thr + Thr-Hys + Pro-Ser

(b) Ala, Arg, Cys, Val, Leu → Ala-Cys + Cys-Arg + Arg-Val + Leu-Ala

9. Show all steps in the synthesis of Gly-Met-Ser using the benzyloxycarbonyl group as a protecting group.

10. The synthesis of polypeptide containing lysine requires the protection of both amino groups. Show how you might do this in synthesis of Lys-Ile using the benzyloxycarbonyl group as a protecting group.

3. Laboratory work.

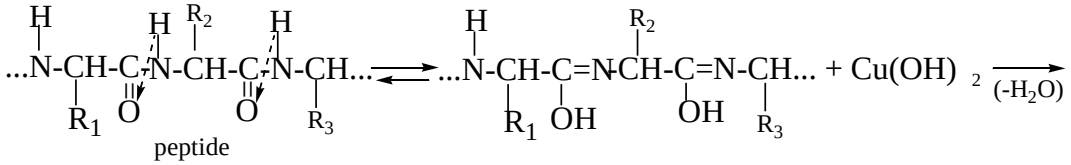
Experiment 1. Biuret test on peptide linkage.

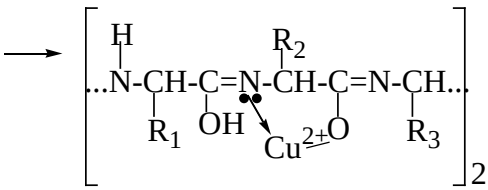
Sequence of operations: Place 5-6 drops of white egg solution (the white protein) in the test-tube. Add 5-6 drops of 2 M NaOH solution and add 1-2 drops of copper (II)-sulphate ($CuSO_4$) solution alongside the test-tube.

Check the result: red-violet colour.

Write:

$$CuSO_4 + 2NaOH \longrightarrow Cu(OH)_2\downarrow + Na_2SO_4$$





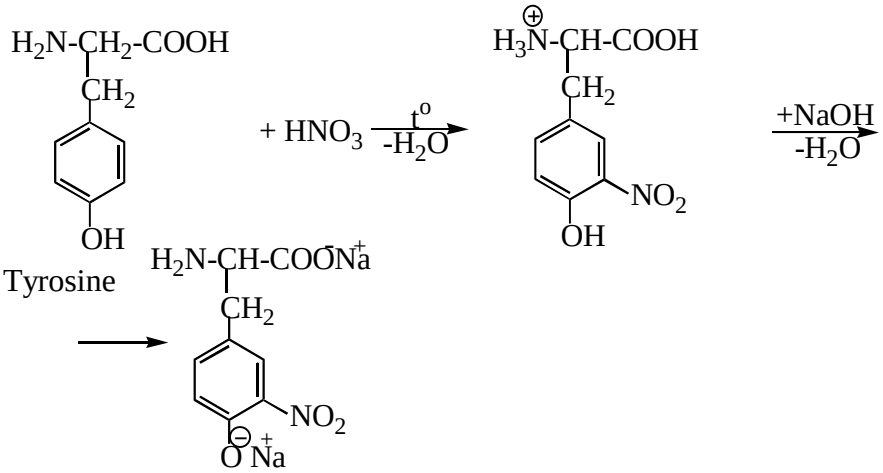
Explain the result and write conclusion.

Experiment 2. Xanthoproteinic test.

Sequence of operations: Place 5 drops of white egg (the white protein) solution in a test-tube. Add 2 drops of concentrated nitric acid. Warm the test-tube carefully, shaking it all the time. Solution and precipitate take in yellow colour. Cool the test-tube. Carefully add 1-3 drops of 2 M NaOH solution.

Check the result: brightly – orange colour.

Write:



Explain the result and write conclusion.

Experiment 3. Three-chlorineacetic acid and sulfosalicylic acid concrets protein.

Sequense of operations: Place 5 drops of white egg (the white protein) solution in test-tube. Add 5 drops of sulfosalicylic acid solution. Repeat this test with three-chlorineacetic acid solution.

Check the result: precipitate of protein.

Explain the result and write conclusion.

Experiment 4. Dehydrating agents concrets protein.

Sequence of operations: Place 5 drops of white egg (the white protein) solution in two test-tubes. Add 10-15 drops of alcohol in the first test-tube, add 10-15 drops of acetone in the second test-tube.

Check the result: precipitate of protein.

Explain the phenomenon, which takes place with protein under the influence of organic solvents **and write conclusions**.

THEME 15
Purine and pyrimidine bases. Nucleosides. Nucleotides. Nucleic acids.

1. Program questions:

1. Composition of nucleic acids. Heterocyclic bases. Structure of DNA and RNA nucleosides and nucleotides.
2. Coenzyme NAD^+, ATP.
3. Medical applications (6-mercaptopurine, allopurinol, acyclovir).
4. DNA: primary and secondary structure. Complementary base pairing. Replication of DNA.

5. RNA: the structure. RNA and protein synthesis. Messenger RNA (mRNA), ribosomal RNA (rRNA) and transfer RNA (tRNA). Messenger RNA synthesis – transcription. The genetic code.

Literature:

[1] L.G. Hidranovich. Bioorganic chemistry lecture course. Vitebsk, 2004. p. 237 - 256

[2] T.W. Graham Solomons. Fundamentals of organic chemistry. John Willey and sons, 1994. p. 1017 - 1039

[3] George H. Schmid. Organic chemistry. Mosby, 1996. p. 1188 - 1205

[4] Richard F. Daley, Sally J. Dalley. Organic chemistry Wm. C. Brown Publishers, 1996. p. 1283 – 1287, 1294 – 1298, 1302 – 1309

2. Problems.

1. Write the sructure of two tautomeric forms of guanine, cytosine, uracil, and thymine.
2. Write structural formulas showing the hydrogen bonds in complementary base pairs of DNA and RNA.
3. The most stable tautomeric form of guanine is the lactam form. This form is normally present in DNA and it pairs specifically with cytosine. Guanine can tautomeraze to the abnormal lactim form and make the pair with thymine. Write structural formulas showing the hydrogen bonds in these base pairs.
4. Nitrous acid (HNO_2) is a potent chemical mutagen. Propose the reaction of adenine's amino group with HNO_2 and show the taumerization of the product.
5. Write the structure and give the name of the nucleoside formed by combining each of the following pairs of heterocyclic bases and pentoses.
   a) Ribose and guanine
   b) Thymine and 2-deoxyribose
   c) Cytosine and ribose
   d) Adenine and 2-deoxyribose
6. Uridine and 2-deoxyguanosine are stable in dilute base. In dilute acid, however, they undergo rapid hydrolysis yilding a sugar and heterocyclic base.Write the reaction of nucleosides hydrolysis.
7. Write structures of 5'-guanilic acid, cytidine –5'-phosphate, 2'-deoxyadenosine-5'-phosphate, uridilic acid. Write the reaction of acid and base-catalyzed hydrolylis of nucleotides.
8. ATP is the abbreviation of adenosine triphoshate. Based on the structure of adenosine 5'-monophoshate, propose a structure for ATP.
9. In some cells, biochemists found a cyclic form of AMP in which the phosphate form a cyclic ester between C3' and C5'. Propose structure for cyclic AMP.
10. Write the structure of mRNA portion with following nucleotides sequences:
    (a) 5'-end U–A–C 3'-end

(b) 5'-end G–U–A 3'-end

11. Write the structure of DNA portion with following nucleotides sequences:
    a. 5'-end A–T–G 3'-end
    b. 5'-end T–G–C 3'-end
12. The portion of one chain of DNA molecule has the following nucleotides sequence:

5'-end AGGCTATTCGT 3'-end. Write the sequence of nucleotides in the complementary chain of the DNA molecule.

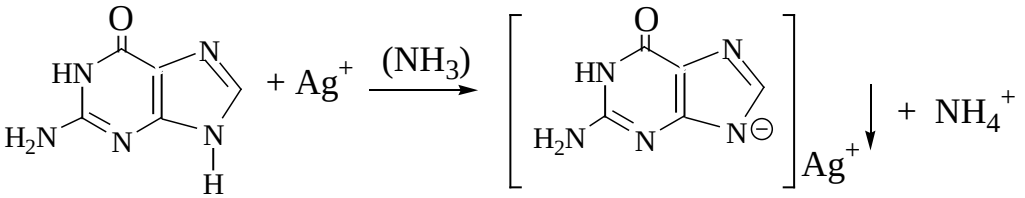
3. Laboratory work.

Experiment 1. Discovering of purine bases ("silver test").

Sequence of operations: Place 5 drops of yeast hydrolysate in a test-tube. Add one by one some drops of concentrated ammonia solution (unti the universal indicator paper will show basic reaction). Then add 5 drops of 2% ammoniacal silver-nitrate solution. Don't mix contents of the test-tube. Leave the test-tube for 3-5 minutes.

Check the result: bright-brown precipitate.

Write:



guanine

Explain the result and write conclusion.

Experiment 2. Discovering five-carbon monosaccacharide in products of nucleotides hydrolysis.

a) Quantitative reaction for aldopentoses (Molish test).

Seguence of operations: Place 5 drops of yeast hydrolyzate in a test-tube. Add 3 drops of 1% thymol alcohol solution. Mix and pour concentrated sulphuric acid along the side the test-tube. Shake the test-tube.

Check the result: there is the test-tube the red coloured product of condensation furfural with thymol on the bottom.

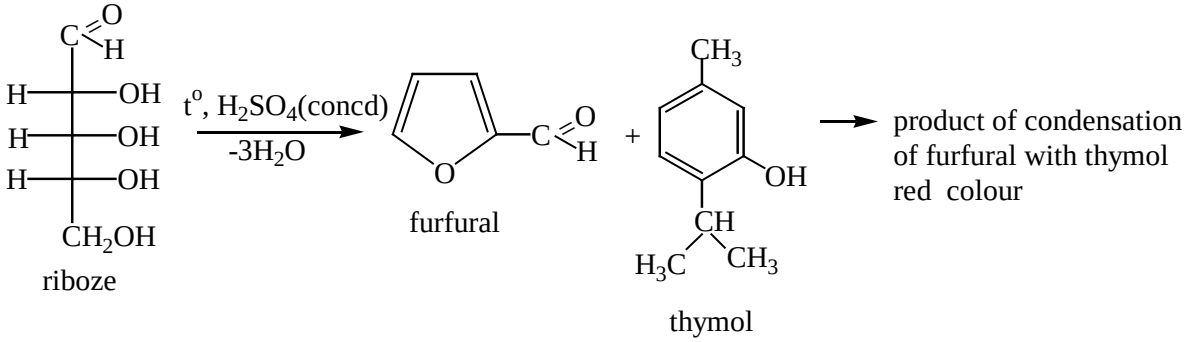
b) Discovering of ribose and deoxyribose.

Seguence of operations: Place 5 drops of yeast hydrolyzate in a test-tube. Add 2 drops of 1% diphenylamine solution. Warm the test-tube on water bath during 15 minutes.

Check the result: blue-green colour.

Remember: 1) concentrated sulphuric acid with five carbon monosaccacharide lead to their dehydration and formation of furfural, which gives red coloured product of condensation with thymol; 2) diphenylamine gives blue colour with deoxyribose, but green colour with ribose.

Write:



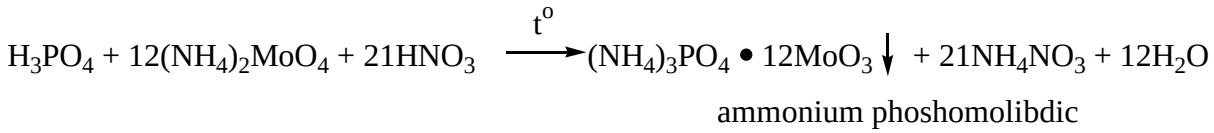
Explain the result and write conclusion.

Experiment 3. Discovering phosphoric acid in product of nucleotides hydrolysis.

Sequence of operations: Place 5 drops of yeast hydrolyzate in the test-tube. Add 10 drops of molibdenic reagent. Warm the test-tube. The liquid becomes lemon-yellow. Cool the test-tube.

Check the result: lemon-yellow precipitate.

Write:



Explain the result and write conclusion.

THEME 16
Lipids.

Program questions:

1.Classification, nomenclature of simple and complex saponifield lipids;

2.The principle structure and stereoisomerism simple and complex saponifield lipids as the basis for the study of the chemical structure of biological membranes;

3.Building principle of major natural higher fatty acids and ω-nomenclature;

4. Properties of simple and complex saponifield lipids and ideas about their role in lipid and mineral metabolism.

Literature:

[1] L.G. Hidranovich. Bioorganic chemistry lecture course. Vitebsk, 2004. p. 256 - 268

[2] T.W. Graham Solomons. Fundamentals of organic chemistry. John Willey and sons, 1994. p. 938-947, 963-967

[3] George H. Schmid. Organic chemistry. Mosby, 1996. p. 675-683

[4] Richard F. Daley, Sally J. Dalley. Organic chemistry Wm. C. Brown Publishers, 1996. p. 192-195, 382-383

2. Problems.

1.How would you convert stearic acid into each of the following?

(a) Ethyl stearate
(b) Sodium stearate
(c) Stearyl chloride
(d) Stearamide
(e) N,N-Dimethylstearamide

2. Illustrate the following reactions of the double bond using oleic acid as an example.

(a) Addition of bromine
(b) Addition of hydrogen
(c) Hydroxylation
(f) Addition of HCI

3. When oleic acid is heated to 180-200^{o}C (in presence of a small amount of selenium), an equilibrium is established between oleic acid (33%) and an isomeric compound called elaidic acid (67%). Suggest a possible structure for elaidic acid.

4. The formation of glycerides raises the question of steochemistry. Glycerol is achiral. Its molecule has a plane of symmetry but many glyceride lipids are chiral due to the loss of molecular symmetry on acylation. Draw the general structures of all possible monoacylglycerols, diacylglycerols and triacylglycerols formed from glycerol and an achiral fatty acid, and specify whether each will be chiral or achiral.

5. Write the structure and name triacylglycerols formed by combining the following fatty acids with glycerol:

(a) Palmitic acid, oleic acid, stearic acid
(b) Linoleic acid, stearic acid, linolenic acid
(c) Oleic acid, linoleic acid, stearic acid.

6. Both triacylglycerols and phospholipids have fatty acid ester components, but only one group can be considered amphipathic. Indicate wich is amphipathic and explain why. Using 1-0-stearoyl-2-0-oleioyl-3-0-palmitoyl-glycerol and lecithin ullustrate yours answer.

7. Write the structure of phosphatidyl serine and show its hydrophilic and hydrophobic portions.

8. Under suitable conditions all of the ester linkages of phosphatide can be hydrolyzed. What organic compounds would you expect to obtain from the complete hydrolysis of (a) lecithin, (b) cephalin, c) choline – containing plasmalogen.

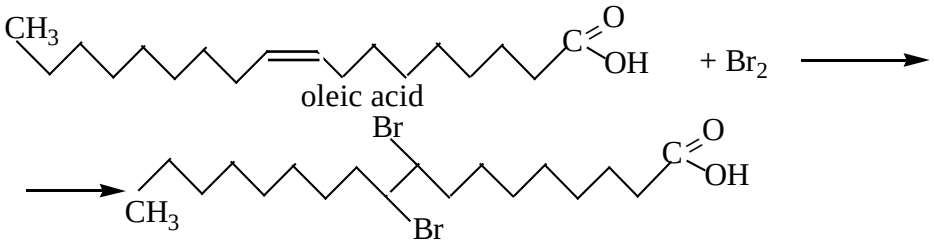
3. Laboratory work.

Experiment 1. Oleic acid reacts with bromine water.

Sequense of operations: Place 3-4 drops of oleic acid in a test-tube. Add 4-5 drops of bromine water.

Check the result: bleaching of solution.

Write:



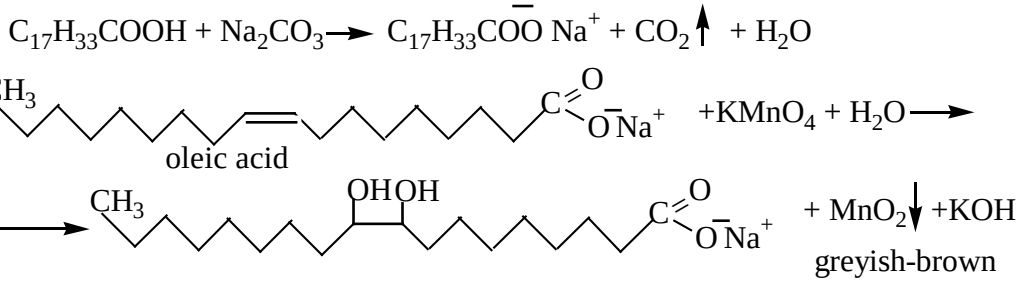
Explain the result and write conclusion.

Experiment 2. Oleic acid reacts with $KMnO_4$ solution.

Sequence of operations: Place 2 drops of oleic acid in a test-tube. Add 2 drops of 5% Na_2CO_3 solution and 2 drops $KMnO_4$ solution. Shake the test-tube.

Check the result: bleaching of solution.

Write:



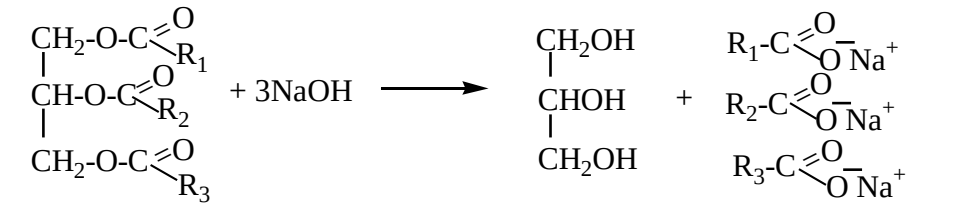
Explain the result and write conclusion.

Experiment 3. Saponification of fats.

Sequense of operations: Place 0,5 ml of castor oil in a test-tube. Add 0,5 ml of alcohol and 0,5 ml of 35% NaOH solution. Mix and warm contents of the test-tube on water bath during 5-7 minutes. Place some drops of solution in a new test-tube, add 2-3 ml of distilled water and warm it. Complete dissolving of the substens in water shows its complete saponification. Add 3-4 ml of saturated hot NaCl solution. (Salting-out soap).

Check the result: layer of soap lift up.

Write:



triacylglycerol — glycerol — salts of fatty acids (soaps)

Explain the result and write conclusion.

THEME 17

TEST № 2: «Biopolimers and their structural units»

I. Program questions for theoretical part of test № 2:

1. Remind yourself the program material from themes №11 - №16.

Literature:

Study the literature from themes № 11 - № 16.

2. **The list of compounds for qualitative functional analysis (student educational-investigative work):**
   1) Benzoic acid;
   2) (+)-tartaric acid;
   3) D-(+)-glucose;
   4) Lactose;
   5) Maltose;
   6) Starch (Amylose and Amylopectin);
   7) Sucrose;
   8) Glycine;
   9) Formaldehyde;
   10) Lactic acid;
   11) Glycerol.

THE EXAMPLE OF THE TASK.

Define, which of the following compounds is present in the task № 100:
D-(+)-glucose or D-sorbitol.

THEME 18

Organic compounds in stomatology

1. Program questions:

1. The structure of macromolecular compounds and classification of polymers;
2. Types of polymerization - radical and ionic polymerization mechanisms and the impact on the structure and properties of polymeric materials;
3. The structure of macromolecular monomers modern composite materials.

Literature:

1. Hurynava, A.S. Restorative dental polymer materials. Vitebsk, 2016.
2. Lecture material.

2. Problems.

1. Explain the following terms:
   - monomer structural unit;
   - degree of polymerization;

- polymers;
- oligomers;
- copolymers.

2. Explain the types of polymerization: radical, ion; the difference in the structure and properties of polymers prepared by different polymerization mechanisms.

3. Explain the radical polymerization reaction mechanism of esters of acrylic and methacrylic acids.

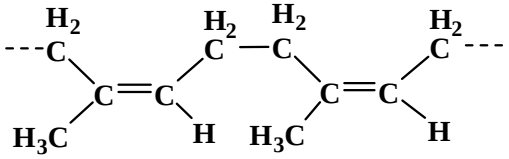
4 Write your explanation for the following terms:

- activators of free radical reactions;
- initiators of free radical reactions;
- polymerization inhibitors of free radical reactions.

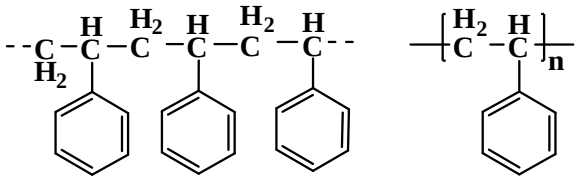
5. Write your explanation for the following terms:

- composite filling materials of chemical and light rejection;
- macromolecular monomers modern composite materials: Bis-GMA, NTG-GMA, HEMA, PMDM, UDVA;
- chemical compounds that are used for binding the restorative material with the tissues of enamel and dentin.

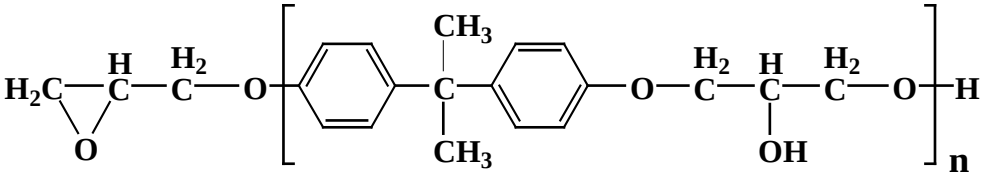
6. Define are the following polymers homochain or heterochain polymers:



Natural rubber: *cis*-1,4-polyisoprene



Polystyrene



Dian epoxy resin

QUESTIONS FOR THE GRADE – CREDIT

in Bioorganic chemistry

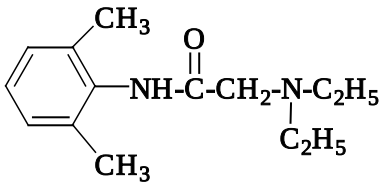
Theoretical bases of structure and organic compound reactivity. Polymers in stomatology.

The grade-credit consists of two steps: practical and theoretical.

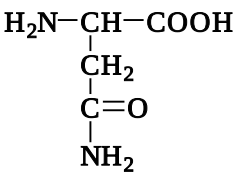
Practical skills paper contains two questions:

1. Classification of organic compounds.

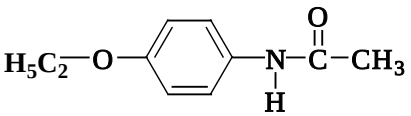
Classify biologically important organic compounds according to the functional groups families. Indicate the functional groups and write the general formulas for founded families of organic compounds.



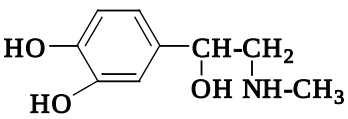
Lidocaine



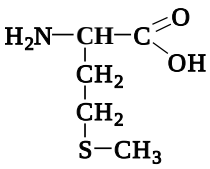
Asparagine



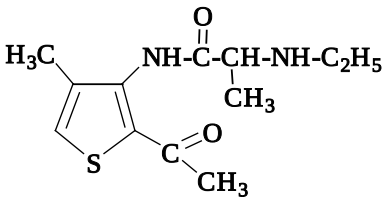
Phenacetine



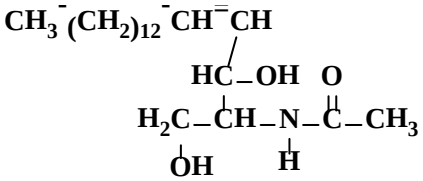
Adrenaline



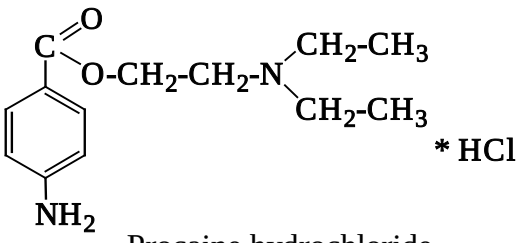
Methionine



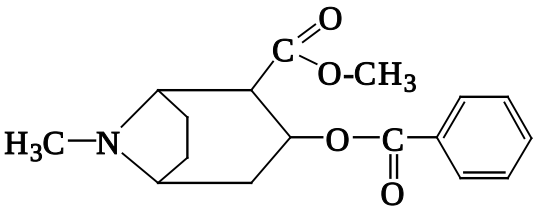
Ultracaine



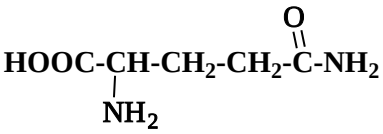
Ceramide



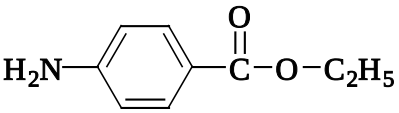
Procaine hydrochloride



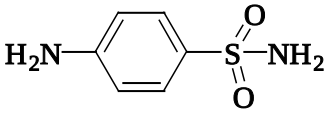
Cocaine



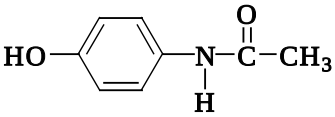
Glutamine



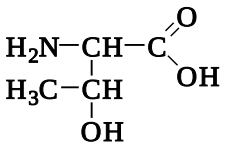
Benzocaine



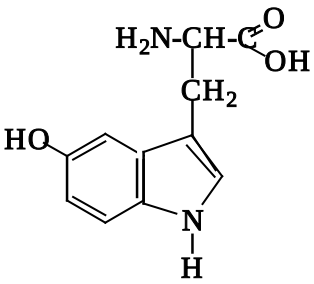
Sulfanilamide



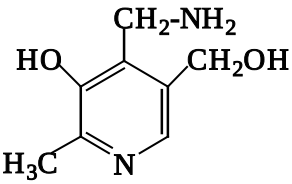
Paracetamol



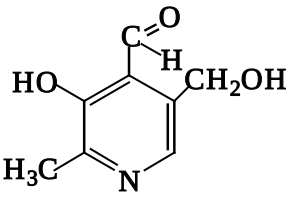
Threonine



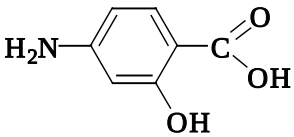
Serotonin



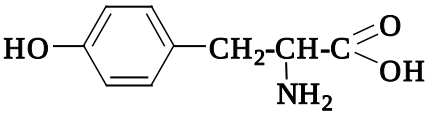
Pyridoxamine



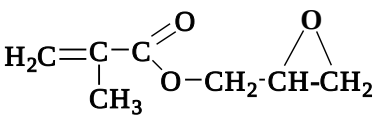
Pyridoxal



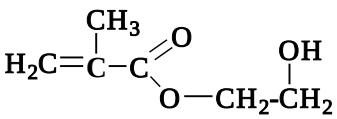
Para-aminosalicylic acid



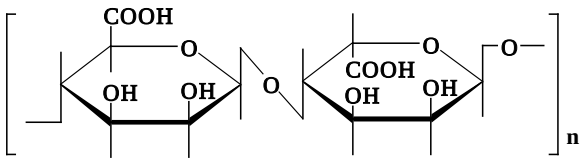
Tyrosine



Glycedyl methacrylat



Hydroxyethyl methacrylat

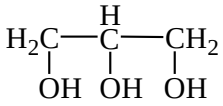
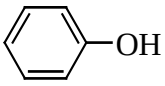
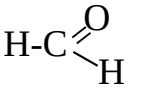
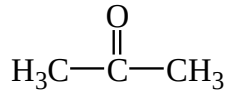
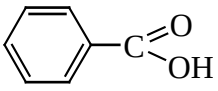
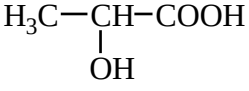
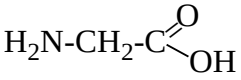
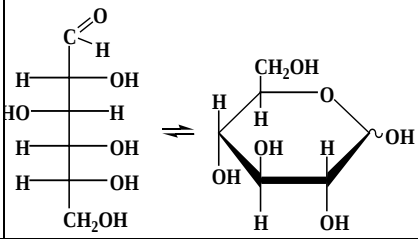
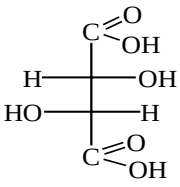
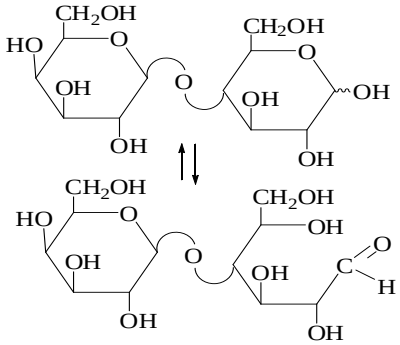


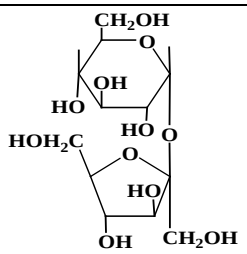
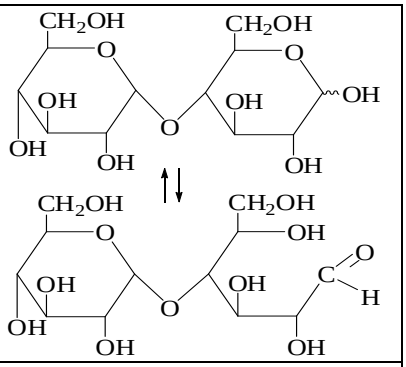
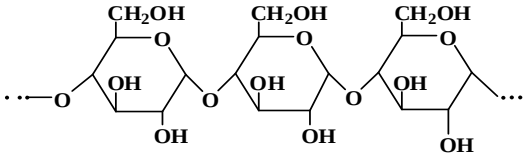
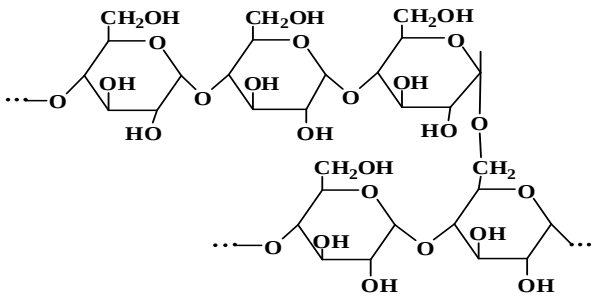
Alginic acid

2. Qualitative functional analysis.

Write the schemes of qualitative reactions and indicate their practical results for the compounds of the following families: alcohols (polyhydric vicinal alcohols), phenols, aldehydes, ketones, carboxylic acids; heterofunctional compounds – hydroxyl acids and amino acids; carbohydrates – monosaccharides, disaccharides and polysaccharides.

The list of compounds for qualitative functional analysis.

The name	The structural formula	The name	The structural formula
1.Glycerol		2.Phenol	
3.Formaldehyde		4.Acetone	
5.Benzoic acid		6.Lactic acid	
7.Glycine		8.D-(+)-glucose	
9.(+)-tartaric acid		10.Lactose	

11.Sucrose		12.Maltose	
13.Starch	 Amylose  Amylopectine		

EXAMPLE OF THE TASK.

Define, which of the following compounds is present in the task № 30:
Sucrose or formaldehyde.

To answer the question of practical skills the student must:

1. Learn by heart the structural formulas of given compounds (1-13).
2. Learn by heart the qualitative reactions for given compounds (1-13) according to the materials given in the laboratory work manuals in the corresponding themes.

Requirements for the answer:

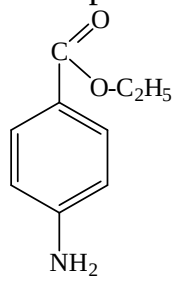
1. To write the structural formulas of both organic compounds (given in the task).
2. To classify both organic compounds according to the functional groups families and principles of classification as bioorganic compounds.
3. To write physical properties of organic compounds: solid or liquid colour, solubitity in water.

4. To write the schemes of qualitative reactions for both organic compounds given in the task. Indicate the results (precipitate, change of the colour and so on).
5. To make the qualitative tests according to the sequence of operations.
6. To write the answer of experimental task (on the base of explanation of the experiment results).

TESTS.

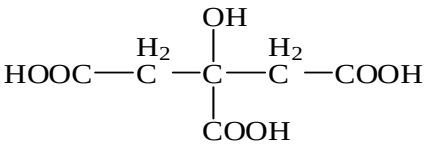
1. CLASSIFICATION AND NOMENCLATURE OF ORGANIC COMPOUNDS.

1. The IUPAC substitutive name of compound is:



- 1. 4-aminobenzoic acid
- 2. ethyl benzoate
- 3. 4-aminobenzyl ethyl ether
+ 4. ethyl 4-aminobenzoate
- 5. anesthesine

2. The IUPAC substitutive name of compound is:



+ 1. 3-carboxy-3-hydroxy-1,5-pentanedioic acid;
- 2. 2-carboxy-2-hydroxy-1,3-propenedioic acid;
- 3. 3-hydroxy-1,3,5-pentanetrioic acid;
- 4. citric acid;
- 5. 3-hydroxy-1,5-pentanedioic acid.

3. The IUPAC substitutive name of threonine is:
+ 1. 2-amino-3-hydroxybutanoic acid;
- 2. 2-amino-4-methylpentanoic acid;
- 3. 2,6-diaminohexanoic acid.
- 4. 2-aminopropanoic acid;
- 5. 2-amino-3-methylbutanoic avid;

4. According to the classification for functional groups 4-hydroxy-3-ethoxybenzaldehyde is:
- 1. ester;
- 2. carboxylic acid;

- 3. alcohol.
- 4. only phenol;
+ 5. aldehyde, phenol and ether;

5. Accoding to the classification for the main chain structure 2-isopropyl-5-methylcyclohexanol is:
+ 1. carbocyclic compound;
- 2. heterocyclic compound;
- 3. unsaturated compound;
- 4. aromatic compound;
- 5. acyclic compound.

6. Pyrimidine is classified as:
- 1. carbocyclic aromatic compound;
+ 2. heterocyclic compound;
- 3. saturated compound;
- 4. aliphatic compound;
- 5. acyclic compound.

7. Glycerol (1,2,3-propanetriol) is:
- 1. monofunctional compound;
+ 2. polyfunctional compound;
- 3. heterofunctional compound;
- 4. cyclic compound;
- 5. aromatic compound.

8. According to the classification for functional groups epinephrine (2-methylamino-1-(3,4-dihydroxyphenyl)ethanol) is:
- 1. thiol;
- 2. ether and primary alcohol;
+ 3. phenol, secondary alcohol and secondary amine;
- 4. carboxylic acid and primary amine;
- 5. only phenol.

9. One of functional group in the structure of procaine (2-(diethylamino)ethyl 4-aminobenzoate) is:
- 1. an alkoxy group;
+ 2. an ester group;
- 3. a secondary amino group;
- 4. a hydroxyl group;
- 5. a carbonyl group.

10. The substitutive IUPAC name of malic acid is:
- 1. 2,3-dihydroxy-1,2-butanedioic acid;
- 2. 2-hydroxypropanoic acid;
- 3. 2-aminopropanoic acid;
+ 4. 2-hydroxy-1,4-butanedioic acid ;
- 5. 1,4-butanedioic acid.

11. The IUPAC substitutive name of glutamine is:
+ 1. 2-amino-4-carbamoylbutanoic acid;
- 2. 2-amino-3-carbamoylpropanoic acid;
- 3. 2-amino-1,5-pentanedioic acid;
- 4. 4-aminopentanoic acid;
- 5. 2-aminoethanoic acid.

3. ELECTRONIC STRUCTURE OF ORGANIC COMPOUNDS.

12. There are only pyridinic heteroatoms in the following compounds:
- 1. 4-ethoxyaniline;
+ 2. ethanal;
- 3. benzoic acid;
- 4. 4-nitrophenol;
- 5. 3-aminopropanoic acid.

13. There are pyrrolic heteroatoms in functional groups of the following families of organic compounds:
+ 1. arylamines;
- 2. saturated aliphatic amines;
- 3. ketones;
- 4. alcohols;
- 5. ethers.

14. There are pyrrolic heteroatoms in functional groups of the following families of organic compounds:
- 1. aldehydes;
- 2. saturated aliphatic amines;
- 3. nitriles;
- 4. alcohols;
+ 5. carboxylic acids.

15. There is π - πconjugation in the structure of the following compounds:
- 1. propanol;

+ 2. pentadiene-1,3;
- 3. pentadiene-1,4;
- 4. propanal;
- 5. propanoic acid.

16. There is π-π conjugation in the structure of the following compounds:
+ 1. benzene;
- 2. cyclohexene;
- 3. pentadiene-1,4;
- 4. propanal;
- 5. propanoic acid.

17. There is p-π conjugation in the structure of the following compounds:
- 1. propanol;
+ 2. 2-hydroxypropanoic acid;
- 3. glycerol;
- 4. pyridine;
- 5. propene-2-al.

18. Covalent sigma bond:
- 1. is formed by side-by-side overlap of p-orbitals:
- 2. has less energy;
+ 3. is formed by end-on overlap of two sp^3 hybrid orbitals;
- 4. is destroyed in the result of the rotation of the molecule part around the bond axis;
- 5. can be easily polarizated.

19. Covalent π-bond:
+ 1. is formed by side-by-side overlap of p-orbitals and can be easily polarizated;
- 2. has high energy;
- 3. is formed by end-on overlap of two sp3 hybrid orbitals;
- 4. is not destroyed in the result of the rotation of the molecule part around the bond axis;
- 5. is not polarised.

20. There are only sp^3 hybrid oxygen atoms in the following compounds:
+ 1. ethoxyethane;
- 2. methoxybenzene;
- 3. phenol;
- 4. 4-hydroxybenzyl alcohol;
- 5. oxaloacetic acid.

21. There are no sp^2 hybrid atoms in the following compounds:
+ 1. glycerol;
- 2. propanoic acid;
- 3. Thymine (2,4-dihydroxy-5-methylpyrimidine);
- 4. phenol;
- 5. aniline.

22. Aromatic compoundis:
- 1. cyclohexane;
- 2. cyclooctatetraene;
- 3.1,3-cyclopentadiene;
- 4. ethylene;
+ 5. benzene.

23. Aromatic compoundis:
- 1. cyclohexane;
- 2. cyclooctatetraene;
- 3. acetylene;
+ 4. pyrrole;
- 5.1,3-cyclopentadiene.

24. The fuctional group has only negative indictive effect in the following compounds:
- 1. phenol;
+ 2. ethylene glycol;
- 3. aniline;
- 4. ethandioic acid;
- 5. methyl phenyl ketone.

25. The fuctional group has negative indictive and negative mesomeric (resonance) effects simultaneously in the following compounds:
- 1. phenol;
- 2. ethylene glycol;
- 3. propanamine-2;
- 4. 1,4-butandioic acid;
+ 5. methyl phenyl ketone.

26. The functional group has negative resonance (mesomeric) effect in the following compound:
- 1. ethanol;
- 2. glycerol;

- 3. acetone;
+ 4. butene-2-al-1;
- 5. 4-methylaniline.

27. The following compound has only electron attracting functional groups:
+ 1.2-aminoethanol-1;
- 2. 2-hydroxybenzoic acid;
- 3. 4-aminobenzenesulfonic acid;
- 4. 4-hydroxy-3-methybenzaldehyde;
- 5. cytosine (4-amino-2-hydroxypyrimidine).

28. Which of the following compound has all functional groups as electron donating:
- 1. 2-isopropyl-5-methylcyclohexanol;
+ 2. 2-isopropyl-5-methylphenol;
- 3. n-aminobenzaldehyde;
- 4. succinic acid (1,4-butanedioic acid);
- 5. 2,3-dihydroxypropanal.

3. STEREOCHEMISTRY OF ORGANIC COMPOUNDS.

29. The Newman projection formulas are used to show the peculiarity of:
- 1. chemical structure of the compound;
+ 2. the conformation of the molecule;
- 3. the constitutional isomers;
- 4. the configuration;
- 5. the structure of E and Z pi-diastereomers.

30. The molecule of 1,2-dimethylcyclohexane has the maximum energy in chair conformation when:
- 1. both methyl groups are placed on the equatorial bonds;
+ 2. both methyl groups are placed on the axial bonds;
- 3. one of the methyl groups is placed on the axial bond;
- 4. one of the methyl groups is placed on the equatorial bond;
- 5. one of the methyl groups is placed on the axial bond and other on the equatorial bond.

31. The potential energy of propanamine-1 *anti*-conformation is less than its *gauche*-conformation because the molecule in *anti*-conformation has:
- 1. less angle strain;
- 2. another configuration;
- 3. less torsional strain;
+ 4. less Van-der-Vaals strain;

- 5. ahother chemical structure.

32. The potential energy of butanol-2 eclipsed conformation is more than its staggered conformation because the molecule in eclipsed conformation has:
- 1. another configuration;
+ 2. more torsional strain and higher Van-der-Vaals repulsion;
- 3. more angle strain;
- 4. less torsional strain;
- 5. another electronic structure;

33. The conformations of 1-chloropropane with torsional angle 60^0 and 300^0 are degenerated because the molecule in these conformations has:
+ 1. the same torsional and Van-der-Vaals strains;
- 2. the same configurations;
- 3. the same chemical structure;
- 4. the different configurations;
- 5. the same electronic structure.

34. The chiral molecule is:
- 1. glycine (2-aminoethanoic acid);
+ 2. proline;
- 3. xylitol;
- 4. butanol-1;
- 5. pentanol-3.

35. The chiral molecules are:
+ 1. D-glucose andalanine;
- 2. citric acid and acetoacetic acid;
- 3. 2-aminoethanol-1;
- 4. adenine;
- 5. furol (2-furancarbaldehyde).

36. 2-aminopropanoic acid has the following number of stereoisomers:
- 1. 1;
+ 2. 2:
- 3. 3;
- 4. 4;
- 5. 5.

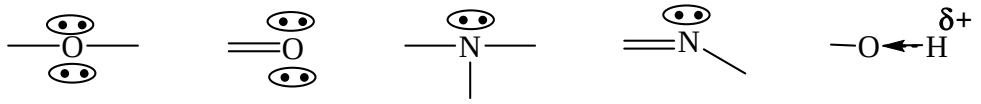
37. 2,3,4-trihydroxybutanal has the following number of stereoisomers:
- 1. 1;
- 2. 2:

- 3. 3;
+ 4. 4;
- 5. 5.

38. 2,3-dihydroxy-1,4-butanedioic acid has the following number of stereoisomers:
- 1. 1;
- 2. 2:
+ 3. 3;
- 4. 4;
- 5. 5.

4. ACID-BASE PROPERTIES OF ORGANIC COMPOUNDS.

39. The acidic reaction centre is:



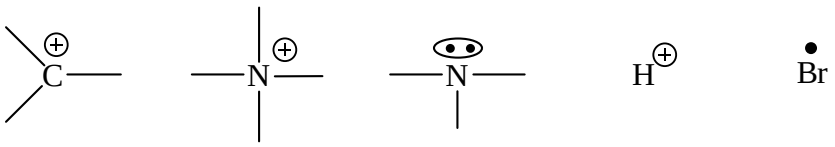
1. 2. 3. 4. 5.

- 1.
- 2.
- 3.
- 4.
+ 5.

40. The functional group of the following family of organic compounds has the OH-acidic reaction centre:
- 1. esters;
- 2. ketones;
+ 3. sulfonic acids;
- 4. acyl chlorides;
- 5. ethers.

41. The functional group of the following family of organic compounds has the NH-acidic reaction centre:
- 1. esters;
- 2. ketones;
- 3. acid anhydride;
+ 4. amides;
- 5. ethers.

42. The basic reaction centre is:



1. 2. 3. 4. 5.

- 1.
- 2.
+ 3.
- 4.
- 5.

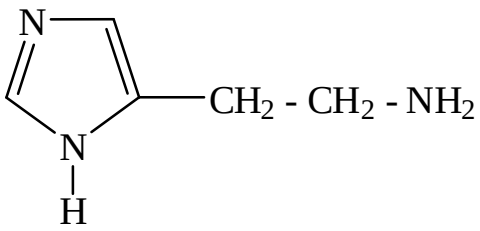
43. The functional group of the following family of organic compounds has the basic reaction centre on the nitrogen atom:
- 1. esters;
- 2. ketones;
+ 3. amines;
- 4. amides;
- 5. ethers.

44. The strongest acidic reaction centre of 3,4-dihydroxyphenylalanine (DOPA) (2-amino-3-(3,4-dihydroxyphenyl)propanoic acid) molecule is:
- 1. CH-acidic centre;
- 2. NH-acidic centre;
- 3. phenol OH group;
+ 4. carboxylic acid OH group;
- 5. amino group.

45. The organic compound with the strongest OH-acidic reaction centre is:
- 1. ethanoic acid;
- 2. propanoic acid;
- 3. 2-methylpropanoic acid;
+ 4. 2,2,2-trichloroethanoic acid;
- 5. 2-aminopropanoic acid.

46. The weakest acid is:
+ 1. ethanamine;
- 2. ethanol;
- 3. phenol;
- 4. ethanoic acid;
- 5. ethanethiol.

47. The strongest basic reaction centre of histamine molecule is:



+ 1. sp^3 hybridized nitrogen atom;
- 2. sp^2 hybridized pyrrole nitrogen atom;
- 3. sp^2 hybridized pyridine nitrogen atom;
- 4. conjugated system with closed chain;
- 5. reactivity of all basic centres are equal.

48. The strongest base is:
- 1. 2-aminoethanol;
- 2. ethanamine;
- 3. methylamine;
+ 4. dimethylamine;
- 5. pyridine.

49. Which of the following compounds have acidic properties and form salts in reaction with strong base:
- 1. pyridine;
- 2. thiophene;
- 3. pyridine;
+ 4. barbituric acid (2,4,6-thrihydroxypyrimidine);
- 5. oxazole (1-aza-3-oxocyclopenta-2,4-diene);

5. CLASSIFICATION AND THE MECHANISMS OF THE REACTIONS IN ORGANIC CHEMISTRY. HYDROCARBONS. S_R, S_E, A_E REACTIONS.

50. According to the product the organic reactions types are:
- 1. bimolecular;
+ 2. addition, substitution and elimination;
- 3. unimolecular;
- 4. nucleophilic;
- 5. synchronic.

51. According to the type of the reagent organic reactions types are:
- 1. bimolecular;
- 2. substitution and elimination;

- 3. unimolecular;
+ 4. nucleophilic and electrophilic;
- 5. synchronic.

52. The bonds are broken by homolysis in the molecules of the following compound:
- 1. HCl;
- 2. CH_3Cl;
+ 3. $CH_3 – CH_3$;
- 4. HCN;
- 5. H_2SO_4.

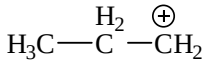
53. The bonds are broken by heterolysis in the molecules of the following compound:
- 1.Br_2;
- 2.$CH_3 – CH_3$;
- 3. Cl_2;
+ 4.$CH_3 – CH_2$ - Cl;
- 5.$CH_3 – CH_2 – CH_3$.

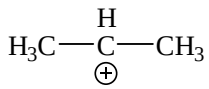
54. The electrophilic reagent is the next of the following:
- 1. ^-OH;
+ 2. Br^+;
- 3. Br^-;
- 4. CH_3-NH_2;
- 5. CH_3-O^-.

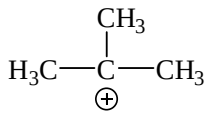
55. The nucleophilic reagent is the next of the following:
+ 1. C_2H_5-NH_2;
- 2. Br^+;
- 3. NO_2^+;
- 4. H^+;
- 5. CH_4.

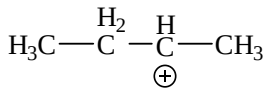
56. The most stable is the following carbocation:

1. 

2. 

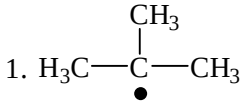
3. 

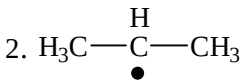
4. 

5. 

-1;
-2;
-3;
+4;
-5.

57. The most stable is the following carbon radical:

1. 

2. 

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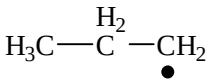
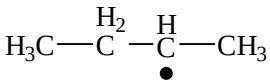
4. 

5. 

+1;
-2;
-3;
-4;
-5.

58. The alkanes react according to the following mechanisms:
- 1. An-E;
- 2. A_R;
- 3. S_E;
+ 4. S_R;
- 5. A_E.

59. The product of the reaction of 2-methylpentane and bromine is:
- 1. 1-bromo-4-methylpentane;
- 2. 2-bromo-4-methylpentane;
- 3. 3-bromo-4-methylpentane;
+ 4. 2-bromo-2-methylpentane;
- 5. 1-bromo-2-methylpentane.

60. The reaction of butane bromation occurs in the following conditions:
- 1. the room temperature;
+ 2. ultraviolet irradiation;
- 3. cooling;
- 4. $AlCl_3$ as catalist;
- 5. the acidic solution.

61. The chlorination reaction occurs as the radical substitution reaction for the following compound:
- 1. cyclohexene;
- 2. benzene;
+ 3. 2-methylbutane;
- 4. acetylene;
- 5. 2-methyl-1,3-butadiene.

62. Alkenes and alkadienes participate in the following reactions:
+ 1. A_E;
- 2. A_N;
- 3. S_E;
- 4. S_R;
- 5. S_N.

63. The reaction of cyclohexene bromation occurs in the following conditions:
+ 1. the room temperature and neutral solution;
- 2. the high temperature;
- 3. ultraviolet irradiation;
- 4. $AlCl_3$ as catalist;
- 5. the acidic solution.

64. The product of 1-pentene hydrobromation is:
- 1.1-bromopentane;
+ 2. 2-bromopentane;
- 3. 3-bromopentane;
- 4. 1,2-dibromopentane;
- 5.pentane.

65. The reaction of 2-butene hydration occurs in the following conditions:
- 1. the room temperature and the neutral solution;
- 2. the excess of NaOH;
- 3. ultraviolet irradiation;
- 4. $FeCl_3$ as catalyst;
+ 5. the acidic catalyst.

66. The product of the 2-methyl-2-butene hydration reaction is:
- 1. 2-methylbutane;
- 2. 2-methyl-1,2-butanediol;
- 3. 2-methyl-2,3-butanediol;
+ 4.2-methyl-2-butanol;
- 5. 3-methyl-2-butanol.

67. The product of the 2-methyl-2-butenoic acid hydration reaction is:
- 1. 2-methylbutane;
- 2. 2-methylbutanal;
- 3. 2-methylbutanoic acid;
- 4. 2-methyl-2-hydroxybutanoic acid;
+ 5. 2-methyl-3-hydroxybutanoic acid.

68. The product of the fumaric acid (*trans*-2-butenedioic acid) hydration reaction is:
- 1. 2-hydroxybutanoic acid;
- 2. 2,3-dihydroxybutanoic acid;
+ 3. 2-hydroxybutanedioic acid;
- 4. 2,3-dihydroxybutanedioic acid;
- 5. citric acid.

69. The product of the aconitic acid (3-carboxy-2-pentenedioic acid) hydration reaction according to the Markovnikov's rule is:
- 1. malic acid;
- 2. lactic acid;
- 3. acetoacetic acid;
- 4. isocitric acid;
+ 5. citric acid.

70. Conjugated alkadienes unlike simple alkenes participate in the following reactions:
- 1. only 1,2-elctrophilic addition;
+2. 1,2- and 1,4-electrophilic addition;

- 3. electrophilic substitution;
- 4. nucleophilic substitution;
- 5. elimination.

71. The reaction of equimolecular 1,3-butadiene bromation results:
- 1. 3-bromo-1-butene;
- 2. 4-bromo-1-butene;
- 3. only 3,4-dibromo-1-butene;
+ 4. 3,4-dibromo-1-butene and 1,4-dibromo-2-butene;
- 5. 1,3-dibromobutane.

72. The product of oxidation of 2-methyl-2-butene with $KMnO_4$ solution (without heating) is:
- 1. 2-methyl-2-butanol;
- 2. acetone and ethanoic acid;
- 3. 2-methylbutane;
- 4. 2-methyl-2,3-epoxybytane;
+ 5. 2-methyl-2,3-butanediol.

73. Qualitative test on unsaturated hydrocarbons can be carried out with following compounds:
- 1. H_2SO_4;
- 2. O_3/H_2O;
+ 3. Br_2, H_2O;
- 4. HBr;
- 5. KCr_2O_7, H_2SO_4 / t^0.

74. Using the reaction with bromine water at the room temperature the following compound can be identified:
- 1. pentane;
+ 2. pentene-2;
- 3. cyclopentane;
- 4. benzene;
- 5. toluene.

75. Qualitative test on unsaturated hydrocarbons can be carried out with following compounds:
- 1. H_2SO_4;
- 2. O_3/H_2O;
- 3. $FeCl_3$;
- 4. HBr;
+ 5. $KMnO_4$, H_2O.

76. The aromatic ring of toluene is characterized by following:
- 1. the acyclic structure;
- 2. $sp^2$and sp^3hybridization types of carbon atoms are present simultaneously;
- 3. absence of the planar structure;
+ 4. cyclic conjugated system withthe number of π-electrons according to the Huckel`s rule: N=4n+2;
- 5. the number of π-electrons corresponds to the equilibrium: $N=2^n$.

77. Benzeneis characterized by the following reactions:
- 1. S_N;
+ 2. S_E;
- 3. S_R;
- 4. oxidation;
- 5. A_E.

78. The reaction of benzene bromation occurs in the following conditions:
- 1. the room temperature;
- 2. ultraviolet irradiation;
- 3. cooling;
+ 4. $AlCl_3$ as catalyst and relatively high temperature;
- 5. pH < 7.

79. The product of phenol bromation with bromine water is:
- 1. 2-bromophenol;
- 2. 3-bromophenol;
- 3. 4-bromophenol;
- 4. 3,5-dibromophenol;
+ 5. 2,4,6-tribromophenol.

80. The reaction of methoxybenzene mononitration results:
+1. 1-methoxy-2-nitrobenzene and 1-methoxy-4-nitrobenzene;
- 2. 1-methoxy-3-nitrobenzene;
- 3. 1-methoxy-2,3-dinitrobenzene;
- 4. 1-methoxy-3,5-dinitrobenzene;
- 5. 1-methoxy-2,3,5-trinitrobenzene.

81. The reaction of benzoic acid with concentrated sulfuric acid in heating results:
- 1. 2-sulfobenzoic acid;
+2. 3-sulfobenzioc acid;
- 3. 4-sulfobenzoic acid;

- 4.3,4-disulfobenzoic acid;
- 5. benzenesulfonic acid.

82. The product of benzaldehyde monomethylation reaction is:
- 1. 2-methylbenzaldehyde;
+2. 3-methylbenzaldehyde;
- 3. 4-methylbenzaldehyde;
- 4. 2,3-dimethylbenzaldehyde;
- 5. methyl phenyl ketone.

83. The reaction of toluene with acetyl chloride in presence of $FeCl_3$ results:
- 1. benzyl methyl ketone;
+2. 2-acetyltoluene and 4-acetyltoluene;
- 3. 3-acetyltoluene;
- 4. 2,3-diacetyltoluene;
- 5. 3,4-diacetyltoluene.

84. The general practical result of toluine oxidation by $KMnO_4/H_2SO_4$in heating is:
- 1. the brown precipitate forming;
+ 2. bleaching of the solution;
- 3. bubbles of the gas;
- 4. no changes;
- 5. change of pH meaning.

6. ALCOHOLS, PHENOLS, THIOLS, AMINES. S_N AND E REACTIONS.

85. Ethanol is:
- 1. secondary alcohol;
+ 2. monohydric primary alcohol;
- 3. polyhydric alcohol;
- 4. aromatic alcohol;
- 5. unsaturated alcohol.

86. Glycerol is:
-1. monohydric primary alcohol;
- 2. dihydric phenol;
+ 3. polyhydric vicinal alcohol;
- 4. tertiary alcohol;
- 5. geminal alcohol.

87. *Tert.*-butyl alcohol is:

- 1. monohydric primary;
- 2. monohydric secondary;
+ 3. monohydric tertiary;
- 4. polyhydric vicinal;
- 5. polyhydric geminal.

88. Propargyl alcohol is:
- 1. primary saturated;
- 2. secondary saturated ;
- 3. tertiary saturated;
+ 4. primary unsaturated;
- 5. secondary unsaturated.

89. Primary aromatic alcohol is:
- 1. methanol;
+ 2. benzyl alcohol;
- 3. isobutul alcohol;
- 4. isopropyl alcohol;
- 5. cyclohexyl alcohol.

90. Primary saturated alcohol is:
- 1. methanol;
- 2. benzyl alcohol;
+ 3. isobutyl alcohol;
- 4. isopropyl alcohol;
- 5. cyclohexyl alcohol.

91. Secondary alcohols are:
+ 1. pentanol-3 andisopropyl alcohol;
- 2. propene-2-ol and propyne-2-ol;
- 3. 2-methylbutanol-2;
- 4. allyl alcohol and benzyl alcohol;
- 5. ethyl alcohol and tert.-butyl alcohol.

92. Tertiary alcohol is:
- 1. 1,2,3-Trihydroxybenzen;
- 2. 2-methylpentanol-3;
+ 3. 2-methylpropanol-2;
- 4. cyclohexanol;
- 5. butanol-2.

93. Accoding to the IUPAC substitutive nomenclature the name of hydroquinone is:
- 1. phenylmethanol;
- 2. cyclohexanol;
- 3. 2-isopropyl-5-methycyclohexanol-1;
- 4. 1,2-dihydroxybenzene;
+ 5. 1,4-dihydroxybenzene.

94. According to the IUPAC substitutive nomenclature the name of ethyl methyl ether is:
- 1. methylthioethane;
+ 2. methoxyethane;
- 3. methoxybenzene;
- 4. 1,2-dimethoxyethane;
- 5. 2-methoxyetanol.

95. The tertiary amine is:
- 1. *tert.*-butylamine;
- 2. isobutylamine;
+ 3. trimethylamine;
- 4. dimethylamine;
- 5. aniline.

96. There are only sp^3 hybrid oxygen atoms in the following compound:
+ 1. glycerol;
- 2. phenol;
- 3. hydroquinone;
- 4. catechol;
- 5. Anisole (methoxybenzene).

97. There are only sp^2 hybrid oxygen atoms in the following compound:
- 1. glycerol;
- 2. 1-propanol;
- 3. diethyl ether;
+ 4. catechol;
- 5. tetrahydrofuran.

98. There are only pyrrole oxygen atoms in the molecules of the following compound:
- 1. glycerol;
+ 2. resorcinol;
- 3. ethanol;

- 4. picric acid (2,4,6-trinitrophenol);
- 5. ethoxyethane.

99. Propanol-1 has following reaction centres:
- 1. NH-acidic and ammonium basic;
- 2. SH-acidic;
- 3. only electrophilic, but not nucleophilic;
+ 4. OH-acidic, basic, electrophilic andnucleophilic;
- 5. it doesn't have any reaction centres.

100. Phenol has following reaction centers:
+ 1. OH-acidic and nucleophilic;
- 2. SH-acidic;
- 3. electrophilic;
- 4. strong basic;
- 5. CH-acidic.

101. One of reaction center of ethanethiol is:
- 1. OH-acidic;
- 2. CH-acidic;
+ 3. SH-acidic;
- 4. NH-acidic;
- 5. electrophilic.

102. The strength of OH-acidic centers increases from left to right in the following order:
- 1. glycerol → ethanol → phenol;
- 2. glycerol → catechol → methanol;
+ 3. isopropyl alcohol → glycerol → resorcinol;
- 4. hydroquinone → glycerol → propanol;
- 5. *o*-cresol → *sec*-butyl alcohol → 1,2,3-propanetriol.

103. Which of the following compounds will react with sodium hydroxide:
- 1. CH_3CH_2OH;
- 2. $C_6H_5CH_2OH$;
+ 3. C_6H_5OH;
- 4. $(CH_3)_2CHOH$;
- 5. $CH_3CH_2CH_2OH$.

104. Phenol is dissolved in:
- 1. the water;
+ 2. the alkaline solution;

- 3. acids;
- 4. the $NaHCO_3$ saturated solution;
- 5. the NaCl saturated solution.

105. The chelate complex formation with $Cu(OH)_2$ is qualitative test for discovery of:
- 1. monohydric alcohols;
- 2. primary and secondary alcohols;
- 3. ethers;
+ 4. polyhydric vicinal alcohols;
- 5. phenols.

106. Using the reaction of chelate formation with $Cu(OH)_2$the following compound can be identified:
- 1. phenol;
+ 2. glycerol;
- 3. catechol;
- 4. ethyl alcohol;
- 5. cyclohexene.

107. The general practical result of polyhydric vicinal alcohol complex formation reaction with $Cu(OH)_2$is:
+ 1. dissolving of the $Cu(OH)_2$ light-blue precipitate to give dark-blue solution;
- 2. blue-greene solution ;
- 3. bleaching solution;
- 4. violet colour;
- 5. bubbles of gas.

108. The violet coloured complex product is the result of the reaction of $FeCl_3$ and:
- 1. 2-propanol;
- 2. glycerol;
+ 3. phenol;
- 4. formaldehyde;
- 5. tartaric acid.

109. The strongest base is:
- 1. isobutyl alcohol;
- 2. butanethiol ;
- 3. resorcinol;
- 4. isobutylamine;
+ 5. isobutylmethylamine.

110. The basic reaction centre of ethers on the oxygen atom provides their reactions:
+ 1. with strong acids;
- 2. with strong bases;
- 3. oxidation;
- 4. reduction;
- 5. with electrophiles.

111. Nucleophilic properties of heteroatoms are increasing in range:
+ 1. 2-methylphenol → 2-methylpropanol-1 → 2-methylpropanamine-1;
- 2. 2-ethoxypropane → 2-isopropyl-5 methylphenol → thiophenol;
- 3. methylthiobenzen → methylthioethane → benzenediol-1,4;
- 4. dioxane-1,4 → cyclohexanol → Ethoxybenzen;
- 5. propanthiol → propanol-2 → ethylthioethane.

112. Alcohols as nucleophilic reagents react with the following family of organic compounds:
- 1. thios;
+ 2. carboxylic acids;
- 3. amines;
- 4. phenols;
- 5. alkenes.

113. The tertiary alcohol undergoes the following reactions with the electrophilic centre:
- 1. A_N;
- 2. A_E;
- 3. A_{N-E};
+ 4. S_N1;
- 5. S_N2.

114. In nucleophilic substitution reactions (S_N) alcohol molecule can be:
- 1. a radical reagent;
+ 2. a nucleophilic reagent and a substrate with electrophilic centre;
- 3. an electrophilic reagent and a substrate with nucleophilic centre;
- 4. only a substrate with electrophilic centre;
- 5. only a substrate with nucleophilic centre.

115. Which of the following compound is most reactive in S_N1 reactions as substrate?
- 1. ethanol;

- 2. isobutyl alcohol;
- 3. 2-butanol;
+ 4. 2-methyl-2-propanol;
- 5. cyclohexanol.

116. Which of the following compound is most reactive in S_N2 reactions as substrate?
+ 1. ethanol;
- 2. isobutyl alcohol;
- 3. 2-butanol;
- 4. 2-methyl-2-propanol;
- 5. cyclohexanol.

117. Inversion of configuration takes place at the stereocentre of chiral alcohols molecules in reactions according to the mechanism:
- 1. S_N1;
+ 2. S_N2;
- 3. A_E;
- 4. A_N;
- 5. E1.

118. Which of the following can readily undergo dehydration:
- 1. ethanol;
+ 2. *tert*-butyl alcohol;
- 3. phenol;
- 4. benzyl alcohol;
- 5. acetic acid.

119. Hydroxyl group in phenols is:
- 1. both o,p-directing and deactivating;
+ 2. both o,p-directing and activating;
- 3. both m-directing and activating;
- 4. both m-directing and deactivating;
- 5. only m-direting.

120. Which of the following compound is most reactive in S_E reactions?
+ 1. phenol;
- 2. benzoic acid;
- 3. benzene;
- 4. toluene;
- 5. naphthalene.

121. The main products of the phenol C-methylation reaction (in presence $AlCl_3$) are:
+ 1. 2-methylphenol and 4-methylphenol;
- 2. 3-methylphenol;
- 3. methoxybenzene;
- 4. 3,5-dimethylphenol;
- 5. phenyl acetate.

122. The reaction of phenol with methylchloride in alkaline solution mainly results:
- 1. 2-methylphenol and 4-methylphenol;
- 2. 3-methylphenol;
+ 3. methoxybenzene;
- 4. 3,5-dimethylphenol;
- 5. phenyl acetate.

123. $K_2Cr_2O_7$ in presence the H_2SO_4 solution in heating oxidizes:
- 1. only primary alcohols;
- 2. only secondary alcohols;
+ 3. primary and secondary alcohols;
- 4. tertiary alcohols;
- 5. ethers.

7. CARBONYL COMPOUNDS. ALDEHYDES AND KETONES. A_N REACTIONS.

124. The reaction centres of aldehydes are:
+ 1. electrophilic, basic, alfa-CH-acidic;
- 2. only nucleophilic and basic;
- 3. only nucleophilic, basic and OH-acidic;
- 4. only electrophilic and nucleophilic;
- 5. only basic and alfa-CH-acidic.

125. Aromatic hydrocarbons that have oxo-group, with straight bonding to the aromatic ring have no following reaction centres:
- 1. electrophilic;
- 2. electrophilic and basic;
- 3. basic, electrophilic, alfa-CH-acidic;
+ 4. alfa-CH-acidic;
- 5. basic.

126. Cyclohexanone is classified as:

- 1. aliphatic aldehyde;
- 2. aromatic aldehyde;
- 3. aromatic ketone;
+ 4. carbocyclic ketone;
- 5. heterocyclic ketone.

127.Aldehydes and ketones are characterized by the following reactions:
- 1. S_E;
- 2.S_N;
- 3.A_E;
+ 4.A_N;
- 5.S_R.

128. Aldehydes and ketones are not characterized by the following reactions:
- 1. A_N;
- 2. A_N-E;
- 3. reduction and oxidation;
- 4. reactions of alfa-CH-acidic centre.
+ 5. S_N.

129. The most reactive in A_N reactions is:
- 1. ethanal;
+ 2. chloral (2,2,2-trichloroethanal);
- 3. acetone;
- 4. methyl phenyl ketone;
- 5. 2,2-dimethylpropanal.

130. The role of acid catalyst in A_N reactions of aldehydes and ketones is:
- 1. increasing of electrophilic carbon opening;
- 2. changing of configuration;
- 3. decreasing of electrophilic centre carbon positivity and reactivity;
+ 4. increasing of electrophilic centre carbon positivity and reactivity;
- 5. leaving group formation.

131. The product of the addition reaction of water to the aldehyde is:
- 1. ketone;
- 2. ester;
- 3. vicinal alcohol;
+ 4. geminal dihydric alcohol;
- 5. hemiacetal.

132. The final product of the reaction between ethanol and propanal in presence of gaseous HCl is:
- 1. ethyl propanoate;
- 2. propyl ethanoate;
+ 3. 1,1-diethoxypropane;
- 4. 1,1-dipropoxyethane;
- 5. 1-ethoxypropane.

133. The 1,1-dimethoxyethane acid catalyzed hydrolysis reaction results:
- 1. methanol and ethanol;
+ 2. methanol and ethanal;
- 3. methanal and ethanol;
- 4. methanol and ethanoic acid;
- 5. methane and ethanoic acid.

134. 1,1-dimethoxybutane can be synthesized by the reaction between following compounds:
- 1. methanol and butanoic acid;
- 2. butanol and formic acid;
- 3. methanal and butanol;
+ 4. methanol and butanal;
- 5. methanol and butanol.

135. The mechanism of reactions of aldehydes and ketones with amines is:
- 1. A_N;
- 2. S_N;
- 3. E;
+ 4. A_N-E;
- 5. A_E.

136. The reaction of aldehydes and ketones with primary amines gives:
- 1. hemiacetals;
- 2. acetals;
-3. oximes;
+ 4. imines;
- 5. 2,4-dinitrophenylhydrazones.

137. The qualitative test for discovery of a carbonyl group in the structures of aldehydes and ketones can be realized with following compound:
- 1. Br_2 / H_2O;
- 2. Tollen's reagent / t^0;
- 3. $FeCl_3$;

- 4. I_2 / NaOH;
+ 5. 2,4-dinitrophenylhydrazine;

138. Reactions of alfa-CH-acidic reaction centre are possible for the following compound:
- 1. benzaldehyde;
- 2. formaldehyde;
+ 3. acetone;
- 4. 2,2-dimethylbutanal;
- 5. 2-ethyl-2-phenylpentanal.

139. Reactions of alfa-CH-acidic reaction centre are possible for the following compound:
- 1. benzaldehyde
+ 2. ethanal;
- 3. formaldehyde;
- 4. 2,2-dimethylbutanal;
- 5. 2-ethyl-2-isopropylpentanal.

140. The haloform reaction is possible for the following compound:
- 1.formaldehyde;
+ 2. ethanal;
- 3. benzaldehyde;
- 4. formic acid;
- 5. diphenyl ketone.

141. The iodoform test is qualitative test for discovery of an alfa-methylcarbonyl group in the following compound:
+ 1. acetone;
- 2. diphenyl ketone;
- 3. benzaldehyde;
- 4. formaldehyde;
- 5. methanal.

142. The following compound forms the primary alcohols as the result of the reduction reaction:
- 1. acetone;
+ 2. propanal;
- 3. 2-pentanon;
- 4. methyl propyl ketone;
- 5. acetophenone.

143. 3-methyl-2-butanol can be product of the reduction reaction of the following compound:
- 1. 3-methylbutanal;
- 2. 3-methylpentanal;
+ 3. 3-methyl-2-butanone;
- 4. 2-methyl-3-butanone;
- 5. 2-pentanone.

144. Cupric hydroxide (II)-$Cu(OH)_2$ in the basic solution (in heating) doesn`t oxidize the following carbonyl compound:
- 1. formaldehyde;
- 2. propanal;
+ 3. acetone;
- 4. 3-methylpentanal;
- 5. 2-methylbutanal.

145. As the result of oxidation of benzaldehyde by Tollen`s reagent forms:
- 1. benzyl alcohol and brick-red precitate;
+ 2. benzoic acid (its salt) and silver mirror;
- 3. benzyl alcohol and silver mirror;
- 4. benzene and brick-red precipitate;
- 5. benzoic acid (its salt) and brick-red precipitate.

146. As the result of disproportionation reaction of formaldehyde the following compounds are formed;
- 1. methanol and water;
+ 2. methanol and methanoic acid;
- 3. formic acid and water;
- 4. methanol and hydrogen;
- 5. methanol, methanoic acid, water and hydrogen.

8. CARBOXYLIC ACIDS AND DERIVATIVES. S_N REACTIONS.

147. According to the number of carboxyl groups carboxylic acids can be classified as:
+ 1. Monocarboxylic anddicarboxylic;
- 2. unsaturated;
- 3. saturated;
- 4. aliphatic;
- 5. aromatic.

148. According to the carbon chain structure carboxylic acids can be classified as:

- 1. Monocarboxylic;
- 2.dicarboxylic;
- 3. tricarboxylic;
+ 4. aliphatic and aromatic;
- 5. amino acids.

149. Monocarboxylic aliphatic saturated carboxylic acid is:
+ 1. ethanoic;
- 2. ethanedioic;
- 3. benzoic;
- 4. 2-butenoic acid;
- 5. phthalic acid (1,2-benzene dicarboxylic acid).

150.Monocarboxylic aromatic carboxylic acid is:
- 1. ethanoic;
- 2. ethanedioic;
+ 3. benzoic;
- 4. 2-butenoic acid;
- 5. phthalic acid (1,2-benzene dicarboxylic acid).

151. Dicarboxylic aliphatic acids are:
- 1. acetic acid and butyric acid;
+ 2. oxalic acid (ethanedioic acid) andsuccinic acid (butanedioic acid);
- 3. acrylic acid (propenoic acid);
- 4. isophthalic acid (1,3-benzene dicarboxylic acid);
- 5. benzoic acid.

152. The derivative of carboxylic acid is:
- 1. ethanoic acid;
- 2. ethanal;
- 3. chloroethane;
- 4. ethyl alcohol;
+ 5. methyl benzoate.

153. The derivative of carboxylic acid is:
- 1. ethanoic acid;
+ 2. ethanoyl chloride;
- 3. chloroethane;
- 4. benzaldehyde;
- 5. ethanol.

154. The structure of a carboxyl group is characterized by:

+ 1. sp^2-hybridized carbon and both oxygen atoms formedconjugated system;
- 2. sp^2-hybridized carbon atom and one of both oxygen, and sp^3-hybridized another oxygen;
- 3. the linear geometry;
- 4. the absence of conjugated system;
- 5. the tetrahedral geometry.

155. The electronic structure of a carboxyl group provides following reaction centres in carboxylic acid molecules:
- 1. NH-acidic and basic;
+ 2. OH-acidic, electrophilic and *alfa*-CH acidic;
- 3. SH-acidic and nucleophilic;
- 4. OH-acidic and *beta*-CH-acidic;
- 5. only nucleophilic .

156. Acidity of carboxylic acids occurs in reaction centre:
+ 1. OH-acidic;
- 2. NH-acidic;
- 3. nucleophilic;
- 4. electrophilic;
- 5. basic.

157. Water-soluble carboxylic acids are characterized by:
+ 1. pH < 7;
- 2. neutral aqueous solution;
- 3, pH > 7;
- 4. basic aqueous solution;
- 5. pH=7.

158. Water insoluble carboxylic acids are dissolved in:
- 1. HCl solution;
+ 2. the alkaline solution andthe $NaHCO_3$ saturated solution;
- 3. strong acids;
- 4. H_2SO_4 solution;
- 5. the NaCl saturated solution.

159. In alkaline solution at room temperature is dissolved:
- 1. methyl benzoate;
+ 2. benzoic acid;
- 3. aniline;
- 4. butyl acetate;
- 5. methyl phenyl ether.

160. Relatively strong acidic properties of carboxylic acids among organic compounds are provided by:
+ 1. high polarity of OH-bond of -COOH group and high stability of carboxylate anione;
- 2. low stability of carboxylate anion;
- 3. reactivity of alfa-CH-acidic centre;
- 4. low polarity of OH-bond of –COOH group;
- 5. electrophilic centre.

161. High stability of carboxylate anion is provided by:
- 1. π-π-conjugation;
+2. complete delocalization of its negative charge as result ofp,π-conjugation;
- 3. conjugated system with closed chain;
- 4. localization of its negative charge on one of oxygen atom;
- 5. aromaticity.

162. The order of carboxylic acids: butanoic → malonic (1,3-propanedioic) → oxalic (1,2-ethanedioic) is characterized by the following order of pKa ($pK_{a1}$for dicarboxylic acids):
- 1. 1.23 → 2.83 → 4.81;
- 2. 4.81 → 1.23→ 2.83;
- 3. 2.83 → 4.81 → 1.23;
+ 4. 4.81 → 2.83 → 1.23;
- 5. 2.83 → 1.23 → 4.81.

163. Functional group carboxylic acids derivatives are formed as the result of the following reactions:
- 1. electrophilic addition (A_E);
- 2. nucleoplic addition (A_N);
+ 3. acyl transfer reaction asnucleophilic substitution (S_N).;
- 4. electrophilic substitution (S_E);
- 5. radical substitution.

164. Functional group carboxylic acids derivatives are formed with participating of the following reaction centre:
- 1. OH-acidic;
- 2. alfa-CH-acidic;
+ 3. electrophilic;
- 4. nucleophilic;
- 5. NH-acidic.

165. Thioester is formed as the result of acetic acid reaction with the reagent:
- 1. alcohol/H^+, t;
+ 2. thiol/H^+, t;
- 3. NH_3/t;
- 4. $SOCl_2$/t;
- 5. PCl_5.

166. Product of reaction of butanoic acid with ammonia in prolonged heating is:
- 1. ethylbutanoate;
- 2. butanamine;
- 3. butanoyl chloride;
+ 4. butanamide;
- 5. anhydride of butanoic acid.

167. The reaction of butanoic acid with methanol in heating and presence of acid catalyst results:
- 1. 1,1-dimethoxybutane;
- 2. ethyl propanoate;
- 3. butyl formiate;
- 4. butyl methanoate;
+ 5. methyl butanoate.

168. Acyl transfer reactions of carboxylic acid derivatives occurs in the main reaction centre:
- 1. nucleophilic centre;
+ 2. electrophilic centre;
- 3. NH-acidic centre;
- 4.alfa-CH-acidic centre;
- 5.basic centre.

169. Hydrolysis of carboxylic acid derivatives occurs in the main reaction centre:
- 1. basic centre;
- 2. alfa-CH-acidic centre;
- 3. NH-acidic centre;
+ 4. electrophilic centre;
- 5. nucleophilic centre.

170. The main product of the reaction of acetyl chloride with dipropylamine is:
- 1. ethyldipropylamine;
- 2. acetamide and 2 moll of 1-chloropropane;
+ 3. N,N-dipropylacetamide;

- 4. N-propylacetamide and 1-chloropropane;
- 5. 2-(N,N-dipropyl)ethanoyl chloride.

171. The reaction of ethyl propanoate with methanamine results:
+ 1. N-methylpropanamide and ethanol;
- 2. propanamide and ethoxymethane;
- 3. ethylmethylpropylamine;
- 4. propanoic acid and ethylmethylamine;
- 5. propanol and N-methylethanamide.

172. Ethyl benzoate may be synthesized by the reaction of benzoyl chloride with the following reagent:
- 1. ethane;
- 2. chloroethane;
- 3. ethanoic acid;
+ 4. ethanol;
- 5. ethylene.

173. The original carboxylic acid is resulted hydrolysis reaction ofthe following substrate in the neutral water:
- 1. ethyl ethanoate;
- 2. propanamide;
+ 3. ethanoic anhydride;
- 4. butanenitrile;
- 5. acetamide.

174. The original carboxylic acid is resulted acid-catalyzed hydrolysis reaction ofthe following substrate:
+ 1. ethyl ethanoate;
- 2. propanamine;
- 3. ethane;
- 4. butyl chloride;
- 5. diethyl ether.

175. The base-catalyzed hydrolysis reaction of benzamide is resulted the following products:
- 1. benzoic acid and ammonium salt;
+ 2. benzoic acid salt and ammonia;
- 3. benzene and ammonia;
- 4. phenol and ammonium salt;
- 5. aniline and formic acid salt.

176. In acyl transfer reactions the most reactive is the following acyl compound:
+1. ethanoyl chloride;
- 2. ethanamide;
- 3. methyl ethanoate;
- 4. ethanoic anhydride;
- 5. ethanoic acid.

177. In hydrolysis reactions the most reactive is the following compound:
- 1. ethyl chloride;
- 2. ethanamide;
- 3. methyl ethanoate;
+ 4. ethanoic anhydride;
- 5. hexyl thioester of ethanoic acid.

178. The reaction of myristic acid (tetradecanoic acid) with bromine in presence of small amount of red phosphorus results:
- 1. myristyl chloride;
+ 2. 2-bromomyristic acid;
- 3. 3-bromotetradecanoic acid;
- 4. 12-bromotetradecanoic acid;
- 5. tetradecyl chloride.

179. Which of the following compounds will be easily decarboxylated in heating:
- 1. ethanoic acid;
+ 2. oxalic acid (ethandioic acid);
- 3. benzoic acid;
- 4. propanoic acid;
- 5. butanoic acid.

9. HETEROFUNCTIONAL COMPOUNDS.

180. The heterofunctional compound is the following:
- 1. oxalic acid;
+ 2. oxaloacetic acid;
- 3. malonic acid ;
- 4. glycerol ;
- 5. sorbitol.

181. The hydroxycarboxylic acid is the following:
- 1. oxalic acid;
- 2. oxaloacetic acid;
- 3. malonic acid ;

+ 4. citric acid;
- 5. valeric acid.

182. The strongest acid is the following
+ 1. 2-hydroxypropanoic acid;
- 2. 3-hydroxypropanoic acid;
- 3. 3-hydroxy-3-methylbutanoic acid;
- 4. 4-hydroxybutanoic acid;
- 5. 4-hydroxy-3-methylbytanoic acid.

183. In the molecules of hydroxycarboxylic acids electron accepting interference of α-hydroxyl and carboxyl groups increases strength of the following reaction centers:
- 1. basic;
- 2. nucleophilic;
- 3. basic and nucleophilic;
+ 4. OH-acidic and electrophilic;
- 5. no one.

184. Specific reaction of α-amino acids in mild heating is:
- 1. elimination to give α-beta unsaturated carboxylic acid;
- 2. formation of lactides;
- 3. formation of lactones;
+ 4. formation of diketopiperasines;
- 5. formation of lactams.

185. In mild heating valine usually forms:
- 1. Lactone and H_2O;
- 2. Lactam and H_2O;
- 3. Lactide and H_2O;
+ 4. Diketopiperasine and H_2O;
- 5. 3-methyl-2-butenoic acid and NH_3.

186. Mild heating of lactic acid (2-hydroxypropanoic aicd) lead to formation of:
- 1. Lactone and H_2O;
- 2. Lactamand H_2O;
+ 3. Lactideand H_2O;
- 4. Diketopiperasine and H_2O;
- 5. propenoic acid and H_2O.

187. Heating of lactic acid in presence of concentrated H_2SO_4 lead to formation of the following products:

- 1. methanal and ethanoic acid
+ 2. methanoic acid and ethanal;
- 3. lactone;
- 4. lactide;
- 5. propenoic acid.

188. Gamma-lactone is formed in mild heating of the following compound:
- 1. 2-hydroxybutanoic acid;
- 2. 3-hydroxybutanoic acid;
+3. 4-hydroxypentanoic acid;
- 4. 2-aminopropanoic acid;
- 5. 4-aminobutanoic acid.

189. The reaction of 3-aminobutanoic acid in heating results the following products:
+1. 2-butenoic acid and ammonia;
- 2. 3-butenoic acid and ammonia;
- 3. lactam and the water;
- 4. diketopiperasine and the water;
- 5. lactide and the water.

190. Diketopiperasines are formed in heating of:
+ 1. 2-aminopropanoic acid;
- 2. beta-alanine;
- 3. 2-aminobenzoic acid;
- 4. 4-aminobutanoic acid;
- 5. 3-aminopentanoic acid.

191. Gamma-lactam is resulted the reaction in mild heating of the following compound:
- 1. 2-aminopropanoic acid;
- 2. beta-alanine;
- 3. 2-aminobenzoic acid;
+ 4. 4-aminobutanoic acid;
- 5. 3-aminopentanoic acid.

192. The oxocarboxylic acid is the following:
- 1. oxalic acid;
+ 2. pyruvic acid;
- 3. malonic acid ;
- 4. citric acid;
- 5. valeric acid.

193. The strongest alfa-CH-acidic centre is present in the molecules of the following oxoacids:
- 1. 2-oxobutanoic acid;
- 2. 2-oxopentanoic acid;
+ 3. 3-oxobutanoic acid;
- 4. 4-oxopentanoic acid;
- 5. 2-oxo-3,3-dimethylbutanoic acid.

194. Decarboxylation reaction occurs in heating in presence of diluted sulfuric acid usually for the following compounds:
- 1. 2-hydroxypropanoic acid;
- 2. 3-hydroxypropanoic acid;
+ 3. 2-oxopropanoic acid;
- 4. 4-aminopentanoic acid;
- 5. 5-hydroxyhexanoic acid.

195. Decarboxylation reaction occurs easy at room temperature usually for the following compounds:
- 1. 2-hydroxypropanoic acid;
- 2. 3-hydroxypropanoic acid;
- 3.5-hydroxyhexanoic acid;
- 4. 2-oxopropanoic acid;
+ 5. 3-oxobutanoic acid .

196. The reaction of acetoacetic ester with bromine water and following reaction with $FeCl_3$ proves:
- 1. pi-pi conjugation;
+ 2. the phenomenon of acetoacetic ester keto-enol tautomerism;
- 3. p-pi conjugation;
- 4. ester group;
- 5. carbonyl group.

197. The derivative of *para*-aminobenzoic acid used as pharmaceutical substance is the following compound:
+1. procaine;
- 2. isoniazid;
- 3. sulfamethoxypyridazine;
- 4. sulfanilamide;
- 5. methyl salicylate.

198. The derivative of sulfanilic acid used as pharmaceutical substance is the following compound:
- 1. procaine;
- 2. isoniazid;
+ 3. sulfamethoxypyridazine;
- 4. benzocain;
- 5. methyl salicylate.

199. The derivative of salicylic acid used as pharmaceutical substance is the following compound:
- 1. procaine;
- 2.benzocain;
- 3. sulfamethoxypyridazine;
+ 4. acetylsalicylic acid;
- 5.sulfanilamide.

200. The hydroxycarboxylic acid is the following:
- 1. oxalic acid;
- 2. oxaloacetic acid;
- 3. malonic acid ;
+ 4. tartaric acid;
- 5. valeric acid.

201. The oxocarboxylic acid is the following:
+ 1. oxalacetic acid;
- 2. malic acid;
- 3. malonic acid ;
- 4. citric acid;
- 5. valeric acid.

Carbohydrates. Monosaccharides. Oligosaccharides and polysaccharides.

202. D-glucose is:
- 1. ketopentose;
- 2. polysaccharide;
- 3. aldopentose;
- 4. ketohexose;
+ 5. aldohexose.

203. D-Ribose is:
- 1. ketopentose;
- 2. polysaccharide;

+ 3. aldopentose;
- 4. ketohexose;
-5. aldohexose.

204. D-Xylose is:
- 1. ketopentose;
- 2. polysaccharide;
+ 3. aldopentose;
- 4. ketohexose;
-5. aldohexose.

205. D-mannose is:
- 1. ketopentose;
- 2. polysaccharide;
- 3. aldopentose;
- 4. ketohexose;
+ 5. aldohexose.

206. D-galactose is:
- 1. ketopentose;
- 2. polysaccharide;
- 3. aldopentose;
- 4. ketohexose;
+ 5. aldohexose.

207. D-fructose is:
- 1. disaccharide;
+ 2. ketohexose;
- 3. aldohexose;
- 4. ketopentose;
- 5. aldopentose.

208. D-Ribulose is:
- 1. disaccharide;
-2. ketohexose;
- 3. aldohexose;
+ 4. ketopentose;
- 5. aldopentose

209. D-Xylulose is:
- 1. disaccharide;
-2. ketohexose;

- 3. aldohexose;
+ 4. ketopentose;
- 5. Aldopentose

210. The number of chiral centers in D-glucose is:
- 1. 2;
+ 2. 4;
- 3. 8;
- 4. 16;
- 5. 64.

211. The number of chiral centers in D-mannose is:
- 1. 2;
+ 2. 4;
- 3. 8;
- 4. 16;
- 5. 64.

212. The number of chiral centers in D-galactose is:
- 1. 2;
+ 2. 4;
- 3. 8;
- 4. 16;
- 5. 64.

213. The number of chiral centers in D-Ribose is:
- 1. 2;
+ 2. 3;
- 3. 8;
- 4. 16;
- 5. 64.

214. The number of chiral centers in D-Xylose is:
- 1. 2;
+ 2. 3;
- 3. 8;
- 4. 16;
- 5. 64.

215. The number of chiral centers in D-fructose is:
- 1. 2;
+ 2. 3;

- 3. 8;
- 4. 16;
- 5. 64.

216. The number of chiral centers in D-Ribulose is:
+ 1. 2;
-2. 3;
- 3. 8;
- 4. 16;
- 5. 64.

217. The number of chiral centers in D-Xylulose is:
+ 1. 2;
-2. 3;
- 3. 8;
- 4. 16;
- 5. 64.

218. The open-chain form of D-glucose contains the following functional groups:
+ 1. Hydroxyl and aldehyde;
- 2. Only hydroxyl;
- 3. Only aldehyde;
- 4. Hydroxyl and oxo-group of ketone;
- 5. Only oxo-group of ketone.

219. The open-chain form of D-mannose contains the following functional groups:
+ 1. Hydroxyl and aldehyde;
- 2. Only hydroxyl;
- 3. Only aldehyde;
- 4. Hydroxyl and oxo-group of ketone;
- 5. Only oxo-group of ketone.

220. The open-chain form of D-galactose contains the following functional groups:
+ 1. Hydroxyl and aldehyde;
- 2. Only hydroxyl;
- 3. Only aldehyde;
- 4. Hydroxyl and oxo-group of ketone;
- 5. Only oxo-group of ketone.

221. The open-chain form of D-Ribose contains the following functional groups:
+ 1. Hydroxyl and aldehyde;
- 2. Only hydroxyl;
- 3. Only aldehyde;
- 4. Hydroxyl and oxo-group of ketone;
- 5. Only oxo-group of ketone.

222. The open-chain form of D-Xylose contains the following functional groups:
+ 1. Hydroxyl and aldehyde;
- 2. Only hydroxyl;
- 3. Only aldehyde;
- 4. Hydroxyl and oxo-group of ketone;
- 5. Only oxo-group of ketone.

223. The open-chain form of D-fructose contains the following functional groups:
- 1. Hydroxyl and aldehyde;
- 2. Only hydroxyl;
- 3. Only aldehyde;
+4. Hydroxyl and oxo-group of ketone;
- 5. Only oxo-group of ketone.

224. The open-chain form of D-Ribulose contains the following functional groups:
- 1. Hydroxyl and aldehyde;
- 2. Only hydroxyl;
- 3. Only aldehyde;
+4. Hydroxyl and oxo-group of ketone;
- 5. Only oxo-group of ketone.

225. The open-chain form of D-Xylulose contains the following functional groups:
- 1. Hydroxyl and aldehyde;
- 2. Only hydroxyl;
- 3. Only aldehyde;
+ 4. Hydroxyl and oxo-group of ketone;
- 5. Only oxo-group of ketone.

226. Which of the following compounds are monosaccharides:
- 1. lactose;
+ 2. D-mannose;

- 3. cellobiose;
- 4. glycogen;
- 5. starch.

227. Which of the following compounds are monosaccharides:
- 1. lactose;
+ 2. D-xylulose;
- 3. cellobiose;
- 4. glycogen;
- 5. starch.

228. Which of the following compounds are monosaccharides:
- 1. lactose;
-2. cellulose;
- 3. cellobiose;
- 4. glycogen;
+ 5. D-fructose.

229. Which of the following compounds are monosaccharides:
- 1. lactose;
-2. cellulose;
- 3. cellobiose;
+ 4. D-Ribose;
-5. D-starch.

230. Which of the following compounds are monosaccharides:
- 1. lactose;
-2. cellulose;
- 3. cellobiose;
+ 4. D-galactose;
-5. D-starch.

231. Which of the following compounds are disaccharides:
+ 1. sucrose;
- 2. D-fructose;
- 3. D-glucose;
- 4. starch;
- 5. cellulose.

232. Which of the following compounds are disaccharides:
+ 1. cellobiose;
- 2. D-fructose;

- 3. D-glucose;
- 4. starch;
- 5. cellulose.

233. Which of the following compounds are disaccharides:
- 1. cellulose;
- 2. D-fructose;
- 3. D-glucose;
- 4. starch;
+5. lactose.

234. Which of the following compounds are disaccharides:
- 1. cellulose;
+2. maltose;
- 3. D-glucose;
- 4. starch;
- 5. D-fructose.

235. Which of the following compounds are homopolysaccharides:
- 1. D-mannose;
- 2. heparin;
- 3. lactose;
- 4. maltose;
+ 5. cellulose.

236. Which of the following compounds are homopolysaccharides:
- 1. D-mannose;
- 2. heparin;
+ 3. starch;
- 4. maltose;
- 5. lactose.

237. Which of the following compounds are reducing disaccharides:
- 1. D-glucose;
- 2.D-glucuronic acid;
- 3. sucrose;
- 4. glycogen;
+ 5. maltose.

238. Which of the following compounds are reducing disaccharides:
+ 1.lactose;
- 2.D-glucuronic acid;

- 3. sucrose;
- 4. glycogen;
- 5. D-glucose.

239. Which of the following compounds are reducing disaccharides:
- 1.ribose;
- 2.D-glucuronic acid;
- 3. sucrose;
+ 4. cellobiose;
- 5. D-glucose.

240. D-glucose and L-glucose are:
+ 1. enantiomers;
- 2. diastereomers;
- 3. anomers;
- 4. epimers;
- 5. structural isomers.

241. D-mannose and L-mannose are:
- 1. structural isomers
+ 2. enantiomers;
- 3. diastereomers;
- 4. anomers;
- 5. epimers;

242. D-galactose and L-galactose are:
- 1. structural isomers
- 2. diastereomers;
- 3. anomers;
+ 4. enantiomers;
- 5. epimers;

243. D-ribose and L-ribose are:
+ 1. enantiomers;
- 2. structural isomers
- 3. diastereomers;
- 4. anomers;
- 5. epimers;

244. D-ribulose and L-ribulose are:
- 1. diastereomers;
+ 2. enantiomers;

- 3. anomers;
- 4. epimers;
- 5. structural isomers

245. D-fructose and L-fructose are:
- 1. diastereomers;
- 2. anomers;
- 3. epimers;
- 4. structural isomers
+ 5. enantiomers;

246. D-xylose and L-xylose are:
- 1. anomers;
- 2. epimers;
+ 3. enantiomers;
- 4. structural isomers
- 5. diastereomers;

247. D-mannose and D-glucose are:
- 1. anomers;
- 2. structural isomers;
- 3. enantiomers;
+ 4. epimers;
- 5.π-diastereomers.

248. D-galactose and D-glucose are:
- 1. anomers;
- 2. structural isomers;
- 3. enantiomers;
- 4.π-diastereomers.
+ 5. epimers;

249. Number of tautomeric forms of D-glucose (found in solution) is:
- 1. two;
- 2. three;
- 3. four;
+ 4. five;
- 5. possible only cyclic form of molecule.

250. Number of tautomeric forms of D-galactose (found in solution) is:
- 1. two;
- 2. three;

- 3. four;
+ 4. five;
- 5. possible only cyclic form of molecule.

251. Number of tautomeric forms of D-mannose (found in solution) is:
- 1. one
- 2. two;
- 3. three;
- 4. four;
+ 5. five;

252. Number of tautomeric forms of D-fructose (found in solution) is:
- 1. 1;
- 2. 2;
- 3. 3;
- 4.4;
+ 5. 5.

253. Number of tautomeric forms of D-ribose (found in solution) is:
- 1. 1;
- 2. 2;
- 3. 3;
- 4.4;
+ 5. 5.

254. Choose the carbon atom which determines the property of monosaccharide to stereochemical designation:
- 1. anomeric atom in beta-anomer molecule;
- 2. any stereocenter in monosaccharide molecule;
+ 3. highest number stereocenter;
- 4. second carbon atom in monosaccharide molecule;
- 5. first carbon atom in monosaccharide molecule.

255. Deoxysugars are derivatives of monosaccharides, which have molecules with:
- 1. oxidated oxo-group;
+ 2. one or two hydroxyl-groups replaced by hydrogen atoms;
- 3. hydroxyl group (usually at the second carbon atom) replaced by amino-group;
- 4. oxidated primary hydroxyl-group;
- 5. reducted oxo-group.

256. Aminogroup of aminosugars can easily react with:
- 1. $Cu(OH)_2$;
- 2. C_2H_5OH;
+ 3. HCl;
- 4. NaOH;
- 5. H_2/Pt.

257. Aminogroup of aminosugars can easily react with:
- 1. NaOH;
- 2. KOH;
- 3. Br_2;
+ 4.HCl;
- 5. NaBr

258. D-mannose forms in water solution the following tautomeric forms:
- 1. Only open-chain form;
- 2. open-chain form and two furanose forms;
- 3. open-chain form and two pyranose forms;
- 4. two furanose forms and two pyranose forms;
+ 5. open-chain form, two furanose forms and two pyranose forms.

259. D-glucose forms in water solution the following tautomeric forms:
- 1. Only open-chain form;
- 2. open-chain form and two furanose forms;
- 3. open-chain form and two pyranose forms;
- 4. two furanose forms and two pyranose forms;
+ 5. open-chain form, two furanose forms and two pyranose forms.

260. D-galactose forms in water solution the following tautomeric forms:
- 1. Only open-chain form;
- 2. open-chain form and two furanose forms;
- 3. open-chain form and two pyranose forms;
- 4. two furanose forms and two pyranose forms;
+ 5. open-chain form, two furanose forms and two pyranose forms.

261. D-fructose forms in water solution the following tautomeric forms:
- 1. Only open-chain form;
- 2. open-chain form and two furanose forms;
- 3. open-chain form and two pyranose forms;
- 4. two furanose forms and two pyranose forms;
+ 5. open-chain form, two furanose forms and two pyranose forms.

262. D-ribose forms in water solution the following tautomeric forms:
+ 1. open-chain form, two furanose forms and two pyranose forms;
- 2. open-chain form and two furanose forms;
- 3. open-chain form and two pyranose forms;
- 4. two furanose forms and two pyranose forms;
- 5. only open-chain form.

263. Anomers are:
- 1. D-glucose and D-galactose;
- 2. D-glucose and D-fructose;
+ 3. α-D-glucopyranose and β-D-glucopyranose;
- 4. D-glucose and L-glucose;
- 5. α-D-glucopyranose and α-D-glucofuranose.

264. Anomers are:
- 1. D-mannose and D-galactose;
- 2. D-glucose and D-fructose;
+ 3. α-D-mannopyranose and β-D-mannopyranose;
- 4. D-mannose and L-mannose;
- 5. α-D-mannopyranose and α-D-glucofuranose.

265. Anomers are:
- 1. D-galactose and D-mannose;
- 2. D-glucose and D-fructose;
- 3. D-galactose and L-mannose;
- 4. α-D-mannopyranose and α-D-galactofuranose.
+ 5. α-D-galactopyranose and β-D-galactopyranose;

266. Anomers are:
- 1. D-ribose and D-mannose;
- 2. D-glucose and D-ribose;
- 3. D-galactose and L-mannose;
- 4. α-D-ribopyranose and α-D-galactofuranose.
+ 5. α-D-ribopyranose and β-D-ribopyranose;

267. Epimers are:
- 1. D-glucose and L-glucose;
+ 2. D-glucose and D-galactose;
- 3. α-D-galactopyranose and β-D-galactopyranose;
- 4. D –glucose and D-ribose;
- 5. D-mannose and cellulose.

268. The products of acidic hydrolisys of O-methyl-α-D-galactopyranoside are:
- 1. α,β-D-galactopyranose and CH_3COOH;
- 2. α-D-galactopyranoside and CH_3COOH;
- 3. α-D-galactopyranose and β-D-galactopyranose;
+ 4. α,β-D-galactopyranose and CH_3OH;
- 5. α,β-D-galactopyranose, CH_3COOH and CH_3OH.

269. Aminosugars are derivatives of monosaccharides which have molecules with:
- 1. oxidated oxo-group;
- 2. one or two hydroxyl-groups replaced by hydrogen atoms;
+ 3. hydroxyl group (usually at the second carbon atom) replaced by amino-group;
- 4. oxidated primary hydroxyl-group;
- 5. reducted oxo-group.

270. Glucosides are formed in reaction of monosaccharides with:
- 1. bromine water;
- 2. acetic anhydride;
+ 3. alcohol/HCl;
- 4. H_2/Pt;
- 5. nitric acid.

271. Glucosides are formed in reaction of monosaccharides with:
- 1. Br_2;
- 2. NaOH;
+ 3. alcohol/HCl;
- 4. KOH;
- 5. HNO_3.

272. Glucosides are formed in reaction of monosaccharides with:
- 1. Br_2;
- 2. NaOH;
- 3. LiOH;
- 4. HNO_3.
+ 5. C_2H_5OH/HCl;

273. The conditions of Trommer`s test for D-glycose are following:
- 1. $[Ag(NH_3)_2]OH$, t;
- 2. Br_2/H_2O;
+ 3. $Cu(OH)_2$, NaOH, t;

- 4. HNO_3 (dilut.);
- 5. C_2H_5OH/HCl.

274. Which of the following structural fragments participates in oxidation of D-glucose to form D-glucuronic acid:
+ 1. primary hydroxyl-group with preliminary protection of oxo-group;
- 2. hydroxyl-group at the second carbon atom;
– 3. this is a reduction reaction;
- 4. oxo- and primary hydroxyl-groups;
- 5. oxo-group.

275. Which of the following structural fragments participates in oxidation of D-galactose to form D-galacturonic acid:
+ 1. primary hydroxyl-group with preliminary protection oxo-group;
- 2. hydroxyl-group at the second carbon atom;
– 3. this is a reduction reaction;
- 4. oxo- and primary hydroxyl-groups;
- 5. oxo-group.

276. What information is true for glycosides:
- 1. can be oxidated Br2/H2O;
- 2. has open-chain and cyclic hemiacetal forms;
- 3. can be oxidated by Tollen`s reagent and in conditions of Trommer`s test;
+ 4. can be hydrolyzed at acidic solution and stable at basic solution;
- 5. can be hydrolyzed at basic solution.

277. What information is true for glycosides:
+ 1. can be hydrolyzed in acidic solution;
- 2. not stable at basic solution;
- 3. has open-chain and cyclic hemiacetal forms;
- 4. can be oxidated by Tollen`s reagent and in conditions of Trommer`s test;
- 5. can be hydrolyzed at basic solution.

278. Which of the following compounds are oxidated by Tollen`s reagent and in conditions of Trommer`s test:
- 1. glycosides;
+ 2. reducing disaccharides;
- 3. nonreducing disaccharides;
- 4. cellulose;
- 5. starch.

279. Maltose is:
- 1. monosaccharide;
- 2. nonreducing disaccharide;
- 3. oligopeptide;
+ 4. reducing disaccharide;
- 5. polysaccharide.

280. Lactose is:
- 1. monosaccharide;
- 2. nonreducing disaccharide;
- 3. oligopeptide;
+ 4. reducing disaccharide;
- 5. polysaccharide.

281. Cellobiose is:
- 1. monosaccharide;
- 2. nonreducing disaccharide;
- 3. oligopeptide;
+ 4. reducing disaccharide;
- 5. polysaccharide.

282. Sucrose is:
- 1. monosaccharide;
- 2. dipeptide;
- 3. reducing disaccharide;
+ 4. nonreducing disaccharide;
- 5. polysaccharide.

283. Cellulose is:
- 1. monosaccharide;
- 2. oligosaccharide;
+ 3. homopolysaccharide;
- 4. heteropolysaccharide;
- 5. reducing disaccharide.

284. Starch is:
- 1. monosaccharide;
- 2. oligosaccharide;
+ 3. homopolysaccharide;
- 4. heteropolysaccharide;
- 5. reducing disaccharide.

285. Heparin is:
- 1. monosaccharide;
- 2. oligosaccharide;
- 3. homopolysaccharide;
+ 4. heteropolysaccharide;
- 5. reducing disaccharide.

286. Hyaluronic acid is:
- 1. monosaccharide;
- 2. oligosaccharide;
- 3. homopolysaccharide;
+ 4. heteropolysaccharide;
- 5. reducing disaccharide.

287. What information is true for sucrose:
+ 1. can be hydrolyzed at acidic solution;
- 2. can be hydrolyzed at basic solution;
- 3. can be oxidated by Tollen`s reagent;
- 4. can be oxidated by Tollen`s reagent and in conditions of Trommer`s test;
- 5. oxo-cyclo tautomerization is possible.

288. What information is true for maltose:
- 1. oxo-cyclo tautomerization is not possible;
- 2. is hydrolyzed at basic solution;
- 3. is not oxidated by Tollen`s reagent and in conditions of Trommer`s test;
+ 4. is reducing disaccharide;
- 5. is hydrolyzed at acidic and basic solution.

289. What information is true for starch:
+ 1. consists of amilose and amilopectine;
- 2. is hydrolyzed with D-fructose forming;
- 3. macromolecules consist of β-D-glucopyranose units;
- 4. can be hydrolyzed at basic solution;
- 5. is found in organism of animals.

290. What information is true for glycogen:
- 1. has structure like structure of amilose;
- 2. consists of alfa-D-galactopyranose units;
+ 3. has very branching structure;
- 4. consists of β-D-glucopyranose units;
- 5. is a reducing disaccharide.

291. What information is true for cellulose:
+ 1. consists of beta-D-glucopyranose units;
- 2. D-glucose units are chained in macromolecule by alfa- (1,4)-glycosidic linkage;
- 3. has branching structure;
- 4. is not hydrolyzed in acidic solution;
- 5. consists of alfa-D-glucopyranose units.

292. The products of maltose hydrolysis reaction are:
- 1. D-glucose and D-galactose;
+ 2. D-glucose;
- 3. D-galactose;
- 4. D-fructose;
- 5. L-glucose.

293. The products of lactose hydrolysis reaction are:
- 1. D-glucose and D-fructose;
- 2. D-glucose;
- 3. D-galactose;
- 4. D-fructose;
+ 5. D-glucose and D-galactose.

294. The products of sucrose hydrolysis reaction are:
- 1. D-glucose;
- 2. D-glucose and D-galactose;
- 3. D-galactose;
- 4. D-fructose and D-galactose;
+ 5. D-glucose and D-fructose.

295. The products of cellobiose hydrolysis reaction are:
- 1. D-glucose and D-galactose;
+ 2. D-glucose;
- 3. D-galactose;
- 4. D-fructose;
- 5. L-glucose.

296. Heparin is:
- 1.unbranched polymer of D-glucose connected by α-1,4-glycosidic linkages;
- 2.unbranched polymer of D-glucose connected by β-1,4-glycosidic linkages;
- 3. cellulose derivative;
+ 4. D-glucuronic acid-2-sulfate-β-1,4-N-sulfo-D-glucosamine-6-sulfate-β-1,4;
- 5. D-glucuronic acid-β-1,3-N-acetyl-D-Glucosamine-β-1,4.

297. Hyaluronic acid is:
- 1.homopolysaccharide;
- 2.unbranched polymer of D-glucuronic acid units connected by β-1,4-glycosidic linkages;
- 3. unbranched polymer of D-glucuronic acid units connected by α-1,4-glycosidic linkages;
- 4. D-glucuronic acid-2-sulfate-β-1,4-N-sulfo-D-glucosamine-6-sulfate-β-1,4;
+ 5. D-glucuronic acid-β-1,3-N-acetyl-D-Glucosamine-β-1,4.

Amino acids.

298. Which of the following natural alfa-amino acids have the structure of 2S, 6-diaminohexanoic acid:
- 1. glycine;
- 2. asparagine;
- 3. arginine;
- 4. glutamic acid;
+ 5. lysine.

299. Which of the following natural alfa-amino acids are essential:
- 1. Asn;
+ 2. Met, Phe, Lys;
- 3. Asn, Ala;
- 4. Phe, Ala;
- 5. Val, Lys, Asn.

300. Essential amino acids are:
+ 1. Try, Tht;
- 2. Cys, Asn;
- 3. Ala;
- 4. Val, Cys;
- 5. Try, Ala.

301. Achiral molecule has the following natural alfa-amino acid:
- 1. Glytamine;
- 2. Isoleucine;
- 3. Proline;
+ 4. Glycine;
- 5. Arginine.

302. Neutral alfa-amino acids are:
+ 1. Val, Gly, Ser;
- 2. Glu, Ile;
- 3. Arg;
- 4. Tyr, Glu, Asp;
- 5. Asp.

303. Neutral alfa-amino acidis:
- 1. Lys;
+ 2. Ile;
- 3. Arg;
- 4. Glu;
- 5. Asp.

304. Neutral alfa-amino acidis:
+1. Val;
- 2. His;
- 3. Arg;
- 4. Glu;
- 5. Asp.

305. Non polar amino acid is:
- 1. Ser;
- 2. His;
- 3. Cys;
- 4. Glu;
+ 5. Leu.

306. Non polar amino acid is:
- 1. Asn;
- 2. His;
+ 3. Phe;
- 4. Glu;
- 5. Lys.

307. Polar amino acid is:
- 1. Pro;
+ 2. Ser;
- 3. Phe;
- 4. Glu;
- 5. Ile.

308. Polar amino acid is:
+ 1. Gln;
- 2. Glu;
- 3. Phe;
- 4.Asp;
- 5. His.

309. Negative charged amino acid is:
- 1. Ser;
+ 2. Glu;
- 3. Lys;
- 4.Ala;
- 5. Phe.

310. Negative charged amino acid is:
- 1. Arg;
- 2. Tyr;
+ 3. Asp;
- 4.Val;
- 5. Cys.

311. Positive charged amino acid is:
- 1. Asp;
- 2. Asn;
+ 3. His;
- 4.Val;
- 5. Ser.

312. Positive charged amino acid is:
+ 1. Arg;
- 2. Tyr;
- 3. Asp;
- 4.Val;
- 5. Cys.

313. Positive charged amino acid is:
- 1. Glu;
- 2. Thr;
- 3. Met;
- 4.Leu;
+ 5. Lys.

314. Amino acid 2-amino-4-methylpentanoic acidis:
+ 1. Leucine;
- 2. Valine;
- 3. Alanine;
- 4.Glycine;
- 5. Tryptophan.

315. Amino acid 2-amino-3-mercaptopropanoic acid is:
- 1. Isoleucine;
- 2. Methionine;
- 3. Glutamine;
+ 4.Cysteine;
- 5. Serine.

316. Amino acid 2-amino-3(4-hydroxyphenyl)-propanoic acidis:
+ 1. Tyrosine;
- 2. Proline;
- 3. Glutamine;
- 4.Cysteine;
- 5. Arginine.

317. Basic alfa-amino acid is:
- 1. Ala;
- 2. Ile;
- 3. Ser;
- 4. Glu;
+ 5. Arg.

318. Acidic alfa-amino acid is:
- 1. Thr;
+ 2. Asp;
- 3. Gln;
- 4. Cys;
- 5. Val.

319. Nonpolar natural alfa-amino acid is:
- 1. Gly;
+ 2. Leu;
- 3. Asp;
- 4. Tyr;
- 5. Glu.

320. Polar natural alfa-amino acid is:
- 1. Ala;
- 2. Val;
+ 3. Ser;
- 4. Ile;
- 5. Glu.

321. For identification of alfa-amino acids can be used qualitative reaction with:
- 1. CH_3CH_2OH (H_2SO_4);
+ 2. ninhydrine;
- 3. Br_2;
- 4. CH_3COCl;
- 5. CH_3I.

322. Reaction with nitric acid (HNO_3(concd)) occurs for alfa-amino acids:
- 1. cysteine;
- 2. asparagine;
- 3. isoleucine;
+ 4. tyrosine;
- 5. valine.

323. Qualitative reaction with $(CH_3CO)_2O$ Pb occurs for:
- 1. serine;
+ 2. cysteine;
- 3. tyrosine;
- 4. praline;
- 5. asparagine.

324. Specific reations of alfa-amino acids in heating are:
- 1. formation of salts;
- 2. formation of lactides;
- 3. formation of lactones;
+ 4. formation of diketopiperasines;
- 5. formation of lactams.

325. Decarboxylation reaction occurs easily in:
+ 1. alfa-aminoacids;
- 2. beta-aminoacids;
- 3. gamma-aminoacids;
- 4. delta-aminoacids;
- 5. epsilon-aminoacids.

326. Diketopiperasine forms in heating:
+ 1. 2-aminopropanoic acid;
- 2. beta-alanine;
- 3. 2-hydroxypropanoic acid;
- 4. 4-aminobutanoic acid;
- 5. 3-aminopentanoic acid.

327. In heating beta-amino acids usually occurs:
- 1. decarboxylation;
- 2. formation of lactones;
+ 3. formation of conjugated unsaturated acids;
- 4. formation of diketopiperasines;
- 5. formation of lactams.

328. Alfa-aminoacid lysine (with pI 9,8) has in solution at pH 5 the predominant form of:
- 1. anion;
+ 2. cation;
- 3. dipolar ion;
- 4. nonionized molecules;
- 5. anion or dipolar ion.

329. Alfa-amino acid asparagin (with pI 5,41) has in solution at pH 5,41 the predominant form of:
- 1. anion;
- 2. cation;
+ 3. dipolar ion;
- 4. nonionized molecules;
- 5. anion or cation.

330. Alfa-amino acid threonine (with pI 5,6) has in solution at pH 10 the predominant form of:
+ 1. anion;
- 2. cation;
- 3. dipolar ion;
- 4. nonionized molecule;
- 5. cation or dipolar ion.

331. Alfa-amino acid Glytamine (with pI 5,65) has in solution at pH 1 the predominant form of:
- 1. anion;
+ 2. cation;

- 3. dipolar ion;
- 4. nonionized molecule;
- 5. dianion.

332. Cysteine is the amino acid that contain in its side chain:
- 1. disulfide linkage;
- 2. hydroxy group;
- 3. carboxy group;
+ 4. thiol group;
- 5. aldehyde group.

Peptides and proteins.

333. Macromolecules of peptides and proteins consist of:
- 1. alfa-hydroxy carboxylic acids;
- 2. beta-oxo carboxylic acids;
- 3. dicarboxylic acids;
- 4. gamma-amino carboxylic acids;
+ 5. alfa-amino carboxylic acids.

334. Proteins consist of:
+ 1. alfa-amino acids;
- 2. beta-oxo carboxylic acids;
- 3. dicarboxylic acids;
- 4.hydrocarbons;
- 5. nucleotides.

335. In chemical nature peptides and proteins are:
- 1. polyesters;
+ 2. polyamides;
- 3. polyglycosides;
- 4. polynucleotides;
- 5. polyterpenes.

336. The chemical nature peptide bond is:
- 1. alcohol;
- 2. ester;
- 3. glycoside;
- 4. amine;
+ 5. amide.

337. Proteins and peptides differ in:
+ 1. macromolecular mass and number of amino acid residues in molecule;
- 2. chemical nature of macromolecules;
- 3. number of monosaccharide units;
- 4.type of glycosidic linkages;
- 5. nature of peptide bond.

338. Chemical nature of peptide bond is:
- 1. carboxylic acid;
- 2. primary amine;
+ 3. amide;
- 4. ester;
- 5. glycoside.

339. The structure and properties of peptide bond is characterized by the following:
-1. sp^3 hybridization of each atoms;
-2. tetrahedral configuration;
+3. p,(pi)-conjugation forms delocalized electron structure and, as the result rotation is restricted about the C-N bond;
-4. C-N bond is weak and easy broken in a hydrolysis;
-5. rotation about the C-N bond is free.

340. Primary structure of the tripeptide glycylvalylphenylalanine is:
- 1. Gln-Ser-Phe;
- 2. Phe-Val-Phe;
- 3. Val-Ser-Gly;
- 4. Gln-Val-Phe;
+ 5. Gly-Val-Phe.

341. Primary structure of the tetrapeptide prolylarginylserylglycine is written in example:
- 1. Gly-Ser-Arg-Pro;
+ 2. Pro-Arg-Ser-Gly;
- 3. Glu-Asp-Ser-Gly;
- 4. Pro-Asp-Ser-Glu;
- 5. Pro-Ser-Gly.

342. Primary structure of polipeptides and proteins gives information about the following:
-1. the conformation of the macromolecule;
+2. the sequence of constituent (alfa)-amino acids;

-3. the local conformation of polypeptide backbone;
-4. possibility to be destroyed in the denaturation process;
-5. the dimensional shape of the macromolecule.

343. The isoelectric point of tripeptide Ala-Val-Tyr is in the following pH solution:
-1. acidic;
+2. almost neutral;
-3. basic;
-4. pH=8-10;
-5.pH=10-12.

344. The isoelectric point of tripeptide Met-Pro-Lys is in the following pH solution:
-1. acidic;
-2. neutral;
+3. basic;
-4. weak acidic;
-5.pH=3-5.

345. The isoelectric point of tripeptide Ser-Asp-Gln is in the following pH solution:
+1. acidic;
-2. neutral;
-3. basic;
-4. weak basic;
-5.pH=10-12.

346. N-terminal (alfa)-amino acid residue of polypeptide is identified by the following method:
-1. partial hydrolysis;
-2. using of enzymes called carboxypeptidases;
+3.Sanger method;
-4. Hydrolysis with enzyme called tripsin;
-5. Hydrolysis with enzyme called chymotrypsin.

347. N-terminal (alfa)-amino acid residue of polypeptide is identified by the following method:
-1. partial hydrolysis;
-2. Hydrolysis with enzyme called tripsin;
-3.using of enzymes called carboxypeptidases;
+4.Edman degradation;

-5. Hydrolysis with enzyme called chymotrypsin.

348. C-terminal (alfa)-amino acid residue of polypeptide is identified by the following method:
-1. partial hydrolysis;
+2. using of enzymes called carboxypeptidases;
-3.Sanger method;
-4. Hydrolysis with enzyme called tripsin;
-5. Hydrolysis with enzyme called chymotrypsin.

349. The reagent of Edman degradation as N-terminal residue polypeptide analysis is:
-1. 2,4-dinitrofluorobenzene;
+2. phenyl isothiocyanate;
-3. H_2O / H^+;
-4. H_2O / OH^-;
-5. benzyl chloroformate.

350. The reagent of Sanger method as N-terminal residue polypeptide analysis is:
+1. 2,4-dinitrofluorobenzene with following hydrolysis in H_2O / H^+;
-2. phenyl isothiocyanate;
-3. chymotrypsin;
-4. di-*tert*-butyl carbonate;
-5. benzyl chloroformate.

351. Protection of amino group of the first amino acid to the polypeptide synthesis is carried out by the following reaction:
-1. hydrolysis;
-2. chelate complex formation;
-3. hydration;
+4. acylation with benzyl chloroformate;
-5. alkylation.

352. The reagent for protection of amino group of the first amino acid to the polypeptide synthesis is the following:
-1. H_2O / H^+;
+2. di-*tert*-butyl carbonate;
-3. H_2 / Pt;
-4. Br_2 / NaOH;
-5.$Cu(OH)_2$.

353. Activation of carboxyl group of the first amino acid to the polypeptide synthesis is carried out by the following reaction:
-1. formation of salt with Na_2CO_3;
-2. chelate complex formation;
+3. formation of mixed anhydride with ethyl chloroformate;
-4.hydration;
-5. esterification.

354. The sequence of operations of peptide synthesis strategy is the following:
+1. “protection” of the amino group and “activation” of the carboxyl group of the first amino acid, “protection” of the carboxyl group of the second amino acid, then substitution reaction to the peptide bond formation, then hydratation and then hydrolysis to the removal of “protected” groups.
-2. “protection” of only the amino group of the first amino acid, then substitution reaction to the peptide bond formation, then hydratation to the removal of “protected” group;
-3. only “activation” of the carboxyl group of the second amino acid, then substitution reaction to the peptide bond formation;
-4. only “protection” of the carboxyl group of the second amino acidand then hydrolysis to the removal of “protected” group.
-5. onlysubstitution reaction between two amino acids to the peptide bond formation.

355. Secondary structuren of polipeptides and proteins gives information about the following:
-1. the conformation of the macromolecule;
-2. the sequence of constituent (alfa)-amino acids;
+3. the local conformation of polypeptide backbone;
-4. possibility to be destroyed in the denaturation process;
-5. the dimensional shape of the macromolecule.

356. The secondary structures of polypeptides and poteins are the following:
-1. micells;
-2. lipid bilayer;
+3. (alfa)-helixes and (beta)-pleated sheets;
-4. double helixes;
-5. globules and fibrillas.

357. The adjacent coils of (alfa)-helix in the secondary structure of peptides and proteins are linked by the following bonds:
-1. covalent;
+2. hydrogen;

-3. ionic;
-4. hydrophobic interactions;
-5. peptide.

358. Peptides and proteins macromolecules of their -pleated sheet secondary structure are linked by the following bonds:
-1. covalent;
+2. hydrogen;
-3. ionic;
-4. hydrophobic interactions;
-5. peptide.

359. Tertiary structuref polipeptides and proteins gives information about the following:
-1. the structures of side-chains of constituent (alfa)-amino acids;
-2. the sequence of constituent (alfa)-amino acids;
-3. the local conformation of polypeptide backbones;
-4. possibility to be destroyed in the denaturation process;
+5. the three-dimensional shape of the macromolecule that arises from further foldings superimposed on the coils of helixes.

360. The tertiary structures of polypeptides and poteins are the following:
-1. micells;
-2. lipid bilayer;
-3. (alfa)-helixes;
-4. (beta)-pleated sheets;
+5. globules and fibrillas.

361. The locations of the side chains of nonpolar, hydrophobic amino acids in globular proteins usually are the following:
+1. in the interior of protein, out of contact with the aqueous solvent;
-2. on the surface of the protein;
-3. most often on the surface, but some times in the interior;
-4. in contact with aqueous solvent;
-5. the location is not important.

362. The locations of the side chains of polar charged amino acids in globular proteins usually are the following:
-1. in the interior of protein;
+2. on the surface of the protein, in contact with aqueous solvent;
-3. most often on the surface, but some times in the interior;
-4.out of contact with the aqueous solvent;

-5. the location is not important.

363. The locations of the side chains of uncharged polar amino acids in globular proteins usually are the following:
-1. only in the interior of protein, out of contact with the aqueous solvent;
-2. only on the surface of the protein;
+3. most often on the surface, but some times in the interior;
-4. only in contact with aqueous solvent;
-5. the location is not important.

364. Peptides and proteins macromolecules of their tertiary structure are linked by the following bonds:
-1. only covalent;
-2. only hydrogen;
+3. Disulfide, hydrogen and ionic;
-4. only hydrophobic interactions;
-5. peptide.

365. The qualitative test for discovery of peptide bonds in the structures of polipeptides and proteins is:
-1. iodoform test;
-2. xanthoproteinic test;
-3. reaction with lead(II) acetate;
-4. reaction with ninhydrin;
+5. biuret test.

366. The qualitative test for discovery of aromatic fragments of aromatic side chains in the aromatic amino acid residues of polipeptides and proteins is:
-1. iodoform test;
+2. xanthoproteinic test;
-3. reaction with lead(II) acetate;
-4. reaction with ninhydrin;
-5. biuret test.

367. The qualitative test for discovery of thiol and sulfides groups of side chains in the sulfurous amino acid residues of polipeptides and proteins is:
-1. iodoform test;
-2. xanthoproteinic test;
+3. reaction with lead(II) acetate;
-4. reaction with ninhydrin;
-5. biuret test.

368. Macromolecules of peptides and proteins consist of:
- 1. alfa-hydroxy carboxylic acids;
- 2. beta-oxo carboxylic acids;
- 3. dicarboxylic acids;
- 4. gamma-amino carboxylic acids;
+ 5. alfa-amino carboxylic acids.

369. In chemical nature peptides and proteins are:
- 1. polysters;
+ 2. polyamides;
- 3. polyglycosides;
- 4. polynucleotides;
- 5. polyterpenes.

370. Proteins and peptides differ in:
+ 1. macromolecular mass and number of amino acid residues in molecule;
- 2. chemical nature of macromolecules;
- 3. number of monosaccharide units;
- 4.type of glycosidic linkages;
- 5. nature of peptide bond.

371. Chemical nature of peptide bond is:
- 1. carboxylic acid;
- 2. primary amine;
+ 3. amide;
- 4. ester;
- 5. glycoside.

372. Primary structure of the tripeptide glycylvalylphenylalanine is:
- 1. Gln-Ser-Phe;
- 2. Phe-Val-Phe;
- 3. Val-Ser-Gly;
- 4. Gln-Val-Phe;
+ 5. Gly-Val-Phe.

373. Primary structure of the tetrapeptide prolylarginylserylglycine is written in example:
- 1. Gly-Ser-Arg-Pro;
+ 2. Pro-Arg-Ser-Gly;
- 3. Glu-Asp-Ser-Gly;
- 4. Pro-Asp-Ser-Glu;
- 5. Pro-Ser-Gly.

Nucleosides. Nucleotides. Nucleic acids.

374. Pyrimidinic bases is:
+ 1. uracil;
- 2. uric acid (2,6,8-thrihydroxypurine);
- 3. adenine;
– 4. guanine;
– 5. imidazole (1,3-diazacyclopenta-2,4-diene).

375. Pyrimidinic bases is:
+ 1. tymine;
- 2. adenine;
- 3. arginine;
– 4. guanine;
– 5. glutamine.

376. Pyrimidinic bases is:
- 1. adenine;
+2. cytosine;
- 3. histidine;
– 4. guanine;
– 5. alanine.

377. Pyrimidinic bases is:
- 1. naphthalene;
- 2. adenine;
– 3. guanine;
+ 4. tymine;
– 5. imidazole (1,3-diazacyclopenta-2,4-diene).

378. Purinic bases are:
- 1. uric acid (2,6,8-trihydroxypurine);
+ 2. adenine;
- 3. uracil;
- 4. tymine;
- 5. cytosine.

379. Purinic bases are:
- 1. asparagine;
- 2. proline;
- 3. uracil;
- 4. tymine;
+ 5. guanine.

380. More stable tautomeric form of uracil is:
- 1. lactimic;
- 2. imino-lactimic;
+ 3. lactamic.
- 4. amino-lactamic;
- 5. enolic.

381. More stable tautomeric form of cytosine is:
- 1. lactimic;
- 2. imino-lactimic;
- 3. lactamic;
+ 4. amino-lactamic;
- 5. enolic.

382. More stable tautomeric form of guanine is:
- 1. lactimic;
- 2. imino-lactimic;
- 3. lactamic;
+ 4. amino-lactamic;
- 5. enolic.

383. Monomeric units of RNA are:
- 1. ribose;
+ 2. ribonucleotides;
- 3. phosphoric acid;
- 4. deoxyribonucleotides;
- 5. heterocyclic bases.

384. Monomeric units of nucleic acids are:
- 1. aminoacids;
+ 2. nucleotides;
- 3. alcohols;
- 4. fatty acids;
- 5. heterocyclic bases.

385. Monomeric units of DNA are:
- 1. deoxyribose;
- 2. heterocyclic bases;
- 3. ribonucleotides;
- 4. phosphoric acid;
+ 5. deoxyribonucleotides.

386. Products of acidic hydrolysis of ribonucleotides are:
+ 1. heterocyclic base, prosphoric acid, ribose;
- 2. ribonucleoside;
- 3. ribose, prosphoric acid;
- 4. prosphoric acid;
- 5. deoxyribose, phosphate-ion.

387. Products of basic hydrolysis of deoxyribonucleotides are:
- 1. deoxyribonucleoside;
- 2. deoxyribose, heterocyclic base;
- 3. deoxyribose;
- 4. heterocyclic base, phosphoric acid;
+ 5. deoxyribonucleoside, phosphate-ion.

388. Products of acidic hydrolysis of deoxyribonucleotides are:
- 1. deoxyribose, heterocyclic base;
+ 2. deoxyribose, heterocyclic base, phosphoric acid;
- 3. heterocyclic base, prosphoric acid, ribose;
- 4. deoxyribose, phosphate-ion;
- 5. deoxyribonucleoside.

389. Products of acidic hydrolysis of adenosine are:
- 1. deoxyribose, adenine;
- 2. deoxyribose, adenine, phosphoric acid;
+ 3. adenine, ribose;
- 4. ribose, phosphate-ion;
- 5. ribose, phosphoric acid.

390. Products of acidic hydrolysis of Guanosine are:
- 1. deoxyribose, Guanine;
- 2. deoxyribose, Guanine, phosphoric acid;
+ 3. Guanine, ribose;
- 4. ribose, phosphate-ion;
- 5. ribose, phosphoric acid.

391. Products of acidic hydrolysis of 5`-Thymidilic acid are:
- 1. deoxyribose, thymine;
+ 2. deoxyribose, thymine, phosphoric acid;
- 3. thymine, ribose;
- 4. ribose, phosphate-ion;
- 5. ribose, phosphoric acid.

392. Products of acidic hydrolysis of adenosine 5-monophosphate are:
- 1. deoxyribose, adenine;
+ 2. ribose, adenine, phosphoric acid;
- 3. adenine, ribose;
- 4. ribose, phosphate-ion;
- 5. ribose, phosphoric acid.

393. Products of acidic hydrolysis of Guanosine 5`-monophosphate are:
- 1. guanine, deoxyribose;
- 2. ribose, phosphoric acid.
- 3. guanine, ribose;
- 4. ribose, phosphate-ion;
+ 5. ribose, guanine, phosphoric acid;

394. Products of acidic hydrolysis of 5`-Uridylic acid are:
+ 1. ribose, uracil, phosphoric acid;
- 2. ribose, uracil, phosphate-ion;
- 3. uracil, ribose;
- 4. ribose, phosphate-ion;
- 5. uracil, deoxyribose;

395. Products of acidic hydrolysis of 5`- cytidylic acid are:
- 1. ribose, phosphate-ion;
- 2. ribose, cytosine, phosphate-ion;
- 3. cytosine, ribose;
+ 4. ribose, cytosine, phosphoric acid
- 5. cytosine, deoxyribose;

396. Products of basic hydrolysis of 5`-Thymidilic acid are:
+ 1. phosphate-ion, thymidine;
- 2. deoxyribose, thymine, phosphate-ion;
- 3. thymine, ribose;
- 4. ribose, phosphate-ion;
- 5. ribose, phosphoric acid.

397. Products of basic hydrolysis of adenosine 5-monophosphateare are:
- 1. deoxyribose, adenine;
+ 2. adenosine, phosphate-ion;
- 3. adenine, ribose;
- 4. ribose, phosphate-ion;
- 5. ribose, phosphoric acid.

398. Products of basic hydrolysis of Guanosine 5`-monophosphate are:
- 1. guanine, deoxyribose;
- 2. ribose, phosphoric acid.
- 3. guanine, ribose;
+ 4. guanosine, phosphate-ion;
- 5. ribose, guanine, phosphoric acid;

399. Products of basic hydrolysis of 5`-Uridylic acid are:
- 1. ribose, uracil, phosphoric acid;
+ 2. uridine, phosphate-ion;
- 3. uracil, ribose;
- 4. ribose, phosphate-ion;
- 5. uracil, deoxyribose;

400. Products of basic hydrolysis of 5`- cytidylic acid are:
+ 1. cytidine, phosphate-ion;
- 2. ribose, cytosine, phosphate-ion;
- 3. cytosine, ribose;
- 4. ribose, cytosine, phosphoric acid
- 5. cytosine, deoxyribose;

401. Heterocyclic bases of DNA are:
- 1. adenine, uracil;
+ 2. guanine, thymine;
- 3. uracil, guanine;
- 4. arginine;
- 5. cytosine, histidine.

402. Heterocyclic bases of RNA are:
- 1. thymine, adenine;
- 2. thymine, guanine;
- 3. uracil, alanine;
+ 4. uracil, cytosine;
- 5. proline.

403. Heterocyclic bases of DNA are:
- 1. uracil, thymine;
+ 2. thymine, cytosine;
- 3. tryptophan, adenine;
- 4. deoxyribose, cytosine;
- 5. phenylalanine.

404. Heterocyclic bases of RNA are:
- 1. heparin;
- 2. adenine, thymine;
- 3. ribose, uracil;
- 4. cytosine, thymine.
+ 5. uracil;

405. Thymine is:
- 1. heterocyclic base of RNA;
+ 2. heterocyclic base of DNA;
- 3. nucleotide of RNA;
- 4. nucleotide of DNA;
- 5. nucleic acid.

406. Adenine is:
+ 1. heterocyclic base;
- 2. aminoacid;
- 3. nucleotide of RNA;
- 4. nucleotide of DNA;
- 5. nucleic acid.

407. Guanine is:
- 1. aminoacid;
- 2. nucleotide;
- 3. polysaccharide;
- 4. nucleic acid.
+ 5. heterocyclic base;

408. Uracil is:
- 1. nucleotide;
+ 2. heterocyclic base;
- 3. polysaccharide;
- 4. nucleic acid.
- 5. aminoacid;

409. 5`-Thymidilic acid is:
- 1. Nucleotide of RNA;
+ 2. Nucleotide of DNA;
- 3. heterocyclic base;
- 4. nucleic acid.
- 5. aminoacid;

410. Adenosine 5-monophosphate is:
+ 1. Nucleotide of RNA;
- 2. heterocyclic base;
- 3. nucleic acid.
- 4. polysaccharide;
- 5. Nucleotide of DNA;

411. Guanosine 5`-monophosphate is:
- 1. heterocyclic base;
- 2. nucleic acid.
- 3. monosaccharide;
+ 4. Nucleotide of RNA;
- 5. Nucleotide of DNA;

412. 5`-Uridylic acid is:
- 1. Amino acid;
- 2. nucleic acid.
+ 3. Nucleotide of RNA;
- 4. Nucleotide of DNA;
- 5. Carboxylic acid;

413. 5`- Cytidylic acid is:
+ 1. Nucleotide of RNA;
- 2. Nucleotide of DNA;
- 3. nucleic acid.
- 4. Carboxylic acid;
- 5. Amino acid;

414. Heterocyclic bases of DNA are:
- 1. adenine, guanine, uracil, thymine, cytosine;
+ 2. adenine, guanine, thymine, cytosine;
- 3. uracil, adenine, guanine;
- 4. deoxyribose, adenine, guanine, thymine, cytosine;
- 5. cytosine, ribose, guanine, thymine.

415. Heterocyclic bases of RNA are:
- 1. thymine, adenine, guanine, uracil, cytosine;
- 2. adenine, thymine, guanine, cytosine;
- 3. ribose, uracil, adenine, guanine;
+ 4. adenine, guanine, uracil, cytosine;
- 5. cytosine, thymine, guanine.

416. Choose conditions for hydrolysis reaction of nucleosides:
- 1. water;
+ 2. acidic aqueous solution;
- 3. basic aqueous solution;
- 4. concentrated basic solution;
- 5. concentrated solution of salts.

417. Which of the following reactional centres form hydrogen bonds between complementaric bases:
- 1. nucleophylic;
- 2. electrophylic;
+ 3. acidic and basic;
- 4. basic and electrophylic;
- 5. nucleophylic and electrophylic.

418. Which of the following reactional centres of nucleotides participate in hydrolysis reactions:
- 1. basic;
- 2. acidic;
- 3. nucleophylic;
+ 4. electrophylic;
- 5. nucleophylic and electrophylic.

419. Guanine pairs with following base in DNA:
- 1. adenine;
+ 2. cytosine;
- 3. tymidine;
- 4. 6-N-methyladenine;
- 5. uracil.

420. Thymine pairs with following base in DNA:
+ 1. adenine;
- 2. cytosine;
- 3. uracil;
- 4. guanine;
- 5. hypoxanthine (6-hydroxypurine).

421. Cytosine pairs with following base in DNA:
- 1. thymine;
- 2. thymine or uracil;
- 3. uracil;
+ 4. guanine;

- 5. purine.

422. Adenine pairs with following base in DNA:
+ 1. thymine;
- 2. cytosine;
- 3. uracil;
- 4. guanine;
- 5. purine.

423. RNA nucleosides is:
- 1. adenosine 5-monophosphate;
- 2. 5`-Thymidilic acid;
+ 3. uridine;
- 4. cytosine;
- 5. uracil.

424. DNA nucleosides is:
- 1. Guanosine 5`-monophosphate;
+ 2. 2`-Deoxythymidine;
- 3. 5`-Adenylic acid;
- 4. cytidine;
- 5. adenosine.

425. RNA nucleotides are:
- 1. 5`-Uridylic acid;
+ 2. 2`-Deoxyadenosine 5`-monophosphate;
- 3. 2`-Deoxycytidine;
- 4. 5`-Thymidilic acid;
- 5. 2`-Deoxythymidine 5`-monophosphate.

426. DNA nucleotides are:
+ 1. 2`-Deoxythymidine 5`-monophosphate;
- 2. 2`Deoxygyanosine;
- 3. adenosine 5-monophosphate;
- 4. 2`-Deoxycytidine;
- 5. 5`-Uridylic acid.

427. Monomeric units of nucleic acids are:
- 1. Ribose;
- 2. Ribonucleosides;
- 3. Phosphoric acid;
+ 4. Deoxyribonucleotides;

- 5. Heterocyclic bases.

428. The products of the acidic hydrolysis of RNA nucleotides are:
+ 1. Heterocyclic bases, ribose, phosphoric acid;
- 2. Ribonucleosides;
- 3. Ribose;
- 4. 2`-Deoxynucleosides;
- 5. Phosphate ion.

429. The products of the basic hydrolysis of DNA nucleotides are:
- 1. 2`-Deoxynucleosides, phosphoric acid;
- 2. Heterocyclic bases;
- 3. 2`-Deoxyribose;
- 4. 2`-Deoxyribose, phosphoric acid;
+ 5. 2`-Deoxynucleosides, phosphate ion.

430. Hydrolylis of nucleosides undergoes by following conditions:
- 1. aqueous solution;
+ 2. acidic solution;
- 3. basic solution;
- 4. alcohol solution;
- 5. aqueous solution or concd. salt solution.

431. Nucleic acids carry out:
- 1. the receptor functions;
+ 2. the storage of the genetic information and translation of the genetic information to proteins;
- 3. the energy functions;
- 4. syntesis of monosaccharides;
- 5. syntesis of polysaccharides.

432. Primary structure of RNA is represented by:
- 1. linear polypeptide chain;
- 2. helical polysaccharide chain;
- 3. double helix;
+ 4. single chain of polynucleotide;
- 5. linear polysaccharide chain.

433. Secondary structure of DNA is represented by:
- 1. helical polysaccharide chain;
- 2. linear polypeptide chain;
+ 3. double helix of polynucleotides;

- 4. single chain of polynucleotides;
- 5. linear polysaccharide chain.

434. Chemically nature of ATP:
- 1. it is polyribonucleotide;
+ 2. it is nucleosidepolyphosphate;
- 3. it is polypeptide;
- 4. it is coenzyme of oxidoreductases;
- 5. contains in structure esteric bonds.

435. ATP is:
- 1. found in nucleic acid;
- 2. found in peptides;
+ 3. important energy source;
- 4. important source of monosaccharides;
- 5. coenzyme of oxidoreductases.

436. NAD+:
- 1. is hydrolyzed in aqueous solution;
- 2. is found in nucleic acids;
+ 3. is coenzyme of oxidoreductases;
- 4. is polypeptide;
- 5. is nucleosidepolyphosphate.

Saponified lipids.

437. Lipids are:
- 1.low-molecular water-soluble substances;
- 2. high-molecular water-soluble substances;
- 3. water-insoluble biological polymers;
+ 4. low-molecular water-insoluble substances;
- 5. gaseous in the ordinary term substances.

438. Lipids are classified according to hydrolyzation into:
- 1. alfa-amino acids, peptides, proteins;
+ 2. saponified and non-saponified;
- 3. monosaccharides, oligosaccharide, polysaccharide;
- 4. nucleosides, nucleotides;
- 5. ribonucleic acid, desoxyribonucleic acid.

439. According to chemical structure saponified lipids are:
- 1. Isoprenoids;

- 2. derivatives of perhydrocyclopentanophenanthrene;
+ 3. esters;
- 4. polyamides;
- 5. polyhydric alcohols and hemiacetales.

440. According to chemical structure non-saponified lipids are as:
- 1. esters;
- 2. polyesters;
- 3. polyamides;
+ 4. isoprenoids;
- 5. polyhydric alcohols and acetales.

441. Saponified lipids are:
- 1. sterols;
- 2.bile acids;
- 3. terpenoids;
+ 4. phospholipids;
- 5.estrogens.

442. Non-saponified lipids are:
+ 1. Steroids, terpenes and terpenoids;
- 2. fats and oils;
- 3. fats and waxes;
- 4. glycolipids;
- 5. prospnolipids.

443. Saponified lipids are classified into:
- 1. non-hydrolyzed compounds;
- 2. monomers and polymers;
- 3. terpenes (terpenoids) and steroids;
+ 4. simple and complex lipids;
- 5. esters and isoprenoids.

444. Non-saponified lipids are classified into:
- 1. simple and complex lipids;
- 2. fats, waxes, phospholipids;
- 3. proteins and peptides;
- 4. RNA and DNA;
+ 5. terpenes (terpenoids) and steroids.

445. Simple saponified lipids are:
- 1. terpenes and terpenoids;

- 2. steroids;
- 3. glycolipids;
+ 4. fats (and oils);
- 5. phospholipids.

446. Complex saponified lipids are:
- 1. terpenes and terpenoids;
- 2. steroids;
- 3. waxes;
- 4. fats (and oils);
+ 5. Phospholipids.

447. Most of natural fats are formed by fatty acids and:
- 1. monohydric alcohols;
- 2. dihydric alcohols glycol;
+ 3. trihydric alcohol glycerol;
- 4. heterofuctional alcohols;
- 5. any alcohols.

448. The following residues predominate in the molecules of fats:
-1. non-saturated fatty acids;
-2. oleic acid;
-3. linolenic acid;
+4. saturated fatty acids;
-5. linoleic acid;

449. Saturated fatty acid is:
+1. palmitic acid
-2. oleic acid;
-3. linolenic acid;
-4. palmitooleic acid
-5. linoleic acid;

450. Saturated fatty acid is:
-1. linoleic acid
-2. oleic acid;
-3. linolenic acid;
+4. stearic acid
-5. palmitooleic acid;

451. Saturated fatty acid is:
-1. linoleic acid;

-2. oleic acid;
-3. linolenic acid;
-4. palmitooleic acid
+5. myristic acid;

452. Unsaturated fatty acid is:
-1. palmitic acid
+2. oleic acid;
-3. ethanoic acid;
-4. stearic acid
5. myristic acid;

453. Unsaturated fatty acid is:
-1. stearic acid
-2. palmitic acid
-3. ethanoic acid;
-4. myristic acid;
+5. linolenic acid;

454. Following fatty acid contains 16 carbon atoms:
-1. stearic acid
+2. palmitic acid
-3. linolenic acid;
-4. myristic acid;
-5. linolenic acid;

455. Following fatty acid contains 18 carbon atoms:
+1. stearic acid
-2. palmitic acid
-3. palmitooleic acid;
-4. myristic acid;
-5. propanoic acid;

456. The following residues predominate in the molecules of oils:
+1. non-saturated fatty acids;
-2. stearic acid;
-3. palmitic acid;
-4. saturated fatty acids;
-5. butyric acid;

457. Which of the following are the saturated fatty acids:
-1. methanoic acid;

+2. stearic acid;
-3. arachidonic acid;
-4. oleic acid;
-5. linolenic acid;

458. Which of the following are non-saturated fatty acids:
-1. palmitic acid;
-2. stearic acid;
+3. oleic acid;
-4. butyric acid;
-5. myristic acid;

459. Which of the following compounds are the fats:
+1. 3-linoleoil-2-oleoil-1-stearoilglycerol;
-2. 1-palmitoil-2-oleoil-L-glycero-3-phosphocholine;
-3. ethylacetate;
-4. cetylpalmitate;
-5. $C_{31}H_{63}OH$

460. Complex saponified lipids are the following:
-1. fats;
+2. glycerophospholipids;
-3. oils;
-4. waxes;
-5. steroids;

461. According to chemical nature glycerophospholipids are:
-1. Fatty acids
-2. Polyatomic alcohols
-3. ethers
+4. Esters of L-phosphatidic acid
-5. Esters of monoatomic alcohols and fatty acids

462. Components of the cellular membrane bilayer are ambivalent because of their structure. They are:
-1. Solid fats;
-2. Oils;
-3. Waxes;
-4. Terpenoids;
+5. Glycerophospholipids;

463. Saponified lipids as esters are able to undergo hydrolysis in heating:

-1. Only in acidic medium;
-2. Only in basic medium;
+3. Both in acidic and basic medium;
-4. In alcohol solution;
-5. Only in distilled water;

464. The products of fats hydrolysis in basic medium are:
-1. $C_{15}H_{31}COOH+C_{16}H_{33}ONa$;
-2. $C_{15}H_{31}COOH+C_{16}H_{33}OH$;
-3. $C_{15}H_{31}COONa+C_{16}H_{33}ONa$;
+4. $C_{15}H_{31}COONa+C_{16}H_{33}OH$;
-5. There's no correct answer;

465. Products of hydrolysis of 2-linoleoil-3-oleoil-1-stearoil-glycerol in basic medium in heating are glycerol and:
-1. $C_{17}H_{31}COOH$, $C_{17}H_{33}COOH$, $C_{17}H_{35}COOH$;
-2. $C_{17}H_{33}COONa$, $C_{17}H_{35}COONa$, $C_{15}H_{31}COONa$;
-3. $C_{17}H_{33}COOH$, $C_{17}H_{35}COOH$, $C_{15}H_{31}COOH$;
-4. $C_{19}H_{31}COONa$, $C_{17}H_{33}COONa$, $C_{17}H_{35}COOH$
+5. $C_{17}H_{31}COONa$, $C_{17}H_{33}COONa$, $C_{17}H_{35}COONa$

466. The product of hydrogenation of 3-lineoyl-2-palmitoyl-1-stearoylglycerol on the metal catalyst is:
-1. 3-(10,13-dihydroxystearoyl)-2-palmitoyl-1-stearoylglycerol;
-2. 1,2,3-tripalmitoyl glycerol;
+3. 2-palmitoyl-1,3-distearoylglycerol;
-4. 1,2,3-tristearoylglycerol;
-5. 3-lineoyl-2-palmitoyl-1-oleoylglycerol;

467. We can expect the decolouration of the iodine or bromine solution when shaked with the following substances:
+1. 3-linoleoyl-2-oleoyl-1-stearoylglycerol;
-2. 3-palmitoyl-1,2-distearoylglycerol;
-3. 1,2,3-tristearoylglycerol;
-4. C_6H_{14}.
-5. 1,2,3-tripalmitoyl glycerol;

468. Saponified lipids are oxidized in mild conditions ($KMnO_4$, H_2O), if there are following residues in their molecules:
-1. Only saturated carboxylic acids;
+2. Non-saturated carboxylic acids;
-3. OH group is present;

-4. amino group is present;
-5. Aromatic ring is present;

469. In organism remnants of the fatty acids are oxidized by the following ways listed:
-1. Hydroxylation;
+2. Peroxide oxidation and enzyme-mediated oxidation;
-3. oxidation by $KMnO_4$;
-4. oxidation by $K_2Cr_2O_7$;
-5. oxidation by strong acid;

Polymers and dental materials

(These tests were elaborated by A.S. Hurynava)

470. Low molecular compound, that form polymer in the polymerization reaction, is called:
– 1. Polymer;
+ 2. Monomer;
– 3. Inhibitor;
– 4. Activator;
– 5. Initiator.

471. Typical monomer of the restorative dental material is the next:
+ 1. Methacrylic acid;
- 2. Poly(methyl methacrylate);
- 3. Polyethylene;
- 4. Rubber;
- 5. Picric acid.

472. Typical monomer of the restorative dental material is the next:
+ 1. Methyl methacrylate;
- 2. Poly(acrylic acid);
- 3. Polyethylene;
– 4. Methyl propanoate;
- 5. Picric acid.

473. The high molecular monomer of the modern restorative composite polymer materials is:
- 1. Methyl methacrylate;
- 2. N,N-dimethyl-p-toluidine;
+ 3. Bis-GMA:
- 4. Gutta percha;

- 5. Isoprene.

474. The high molecular monomer of the modern restorative composite polymer materials is:
- 1. Methyl acrylate;
- 2. N,N-dimethyl-p-toluidine;
- 3. Gutta percha;
+ 4. Triethylene glycol dimethacrylate (TEG-DMA);
- 5. Ethylene.

475. The high molecular monomer of the modern restorative composite polymer materials is:
- 1. Methyl acrylate;
- 2. N,N-dimethyl-p-toluidine;
– 3. methyl methacrylate;
+ 4. NTG-GMA
- 5. Ethylene.

476. A large molecule (macromolecule) consisted of a number of smaller repeating units (monomer units) is:
+ 1. Polymer;
- 2. Monomer;
– 3. Inhibitor;
– 4. Activator;
– 5. Initiator.

477. The homopolymer is the next:
- 1. Dian epoxy resin;
- 2. Alginic acid;
- 3. Ribonucleic acid;
- 4. Poly(piromellit dimethacrilate);
+ 5. Polymetyl methacrylate.

478. The heterochaine polymer is the next;
- 1. Polyethylene;
- 2. Gutta percha;
- 3. Natural rubber;
+ 4. Dian epoxy resin;
- 5. Polymetyl methacrylate.

479. The product of addition polymerization of isobutylene is:
+ 1. Natural rubber;

- 2. Alginic acid;
- 3. Poly(acrylic acid)
- 4. Dian epoxy resin;
- 5. Polyethylene.

480. The product of addition polymerization of 2,2-di(4-hydroxyphenyl)propane (Bisphenol A)and 3-chlor-1,2-epoxypropane (epychlorhydrine) is:
- 1. Natural rubber;
- 2. Alginic acid;
- 3. Poly(acrylic acid)
+ 4. Dian epoxy resin;
- 5. Polyethylene.

481. The product of depolymerization reactions of poly(butyl acrylate) is:
+ 1. butyl acrylate;
- 2. acrylic acid;
- 3. methyl acrylate;
- 4. piromellit acid;
- 5. hydroxyethyl methacrylate.

482. Substance, that can produce radical species under mild conditions and promote free radical reactions, is called:
+ 1. Initiator;
– 2. Inhibitor;
– 3. Activator;
– 4. Monomer;
– 5. Fotosensibilizator.

483. The initiator of radical polymerization reactions is:
+ 1. Benzoyl peroxide;
- 2. Hydroquinone;
- 3. N,N-dihydroxyethyl-p-toluidine;
- 4. Picric acid;
- 5. Maleic acid.

484. The compound, that prevents the free radical chain reaction from occurring and delay polymerization reaction, is called:
- 1. Initiator;
+ 2. Inhibitor;
– 3. Activator;
– 4. Monomer;

– 5. Fotosensibilizator.

485. The inhibitor of radical polymerization reactions is:
- 1. Benzoyl peroxide;
+2. Hydroquinone;
- 3. N,N-dihydroxyethyl-p-toluidine;
- 4. Picric acid;
- 5. Maleic acid.

486. The compound, which reacts with initiator and produces free radical species at lower temperature than initiator alone, is:
- 1. Initiator;
- 2. Inhibitor;
+ 3. Activator;
– 4. Monomer;
– 5. Oligomer.

487. The compound, which reacts with initiator and produces free radical species on light, is:
- 1. Initiator;
- 2. Inhibitor;
+3. Fotosensibilizator ;
– 4. Monomer;
– 5. Oligomer.

488. The activator of chemically activated polymerization reaction is:
- 1. Benzoyl peroxide;
- 2. Hydroquinone;
+ 3. N,N-dihydroxyethyl-p-toluidine;
- 4. Picric acid;
- 5. Maleic acid.

489. Thefotosensibilizator of light activated polymerization reaction is:
- 1. Benzoyl peroxide;
- 2. Hydroquinone;
- 3. N,N-dihydroxyethyl-p-toluidine;
+4. Camphorquinone;
- 5. Maleic acid.

490. Some primers for adhesion of dental material to the enamel and dentin contain:

- 1. Benzoyl peroxide;
- 2. Hydroquinone;
- 3. N,N-dihydroxyethyl-p-toluidine;
- 4. Picric acid;
+ 5. Maleic acid.

491. Adhesion of a restorative material to the tooth and enamel tissuesis provided with:
+ 1. Dimethacrylate of glycerophoshporic acid;
- 2. Hydroquinone;
- 3. Benzoyl peroxide;
- 4. 1,3,5-trinitrobenzene;
- 5. N,N-dihydroxyethyl-p-toluidine.

492. Adhesion as chemical bonding between amino group of collagen and hydroxyl group of monomer (2-hydroxyethyl methacrylate) is formed with:
- 1. Benzoyl peroxide;
- 2. Hydroquinone;
+ 3. Glutaraldehyde;
- 4. 1,3,5-trinitrobenzene;
- 5. N,N-dihydroxyethyl-p-toluidine.

493. Unsaturation of ethyl methacrylate is discovered by qualitative test with:
- 1. $FeCl_3$;
- 2. $Cu(OH)_2$;
+ 3. Br_2;
- 4. $[Ag(NH_3)_2]OH$, t^0;
- 5. $NaHCO_3$.

494. Unsaturation of methyl methacrylate is discovered by qualitative test with:
- 1. $FeCl_3$;
+ 2. $KMnO_4$, H_2O;
- 3. $Cu(OH)_2$;
- 4. $[Ag(NH_3)_2]OH$, t^0;
- 5. CuO, t^o.

495. According to the classification for functional groups mehtyl methacrylate is:
+1. Alkene and ester;
- 2. Alkene and carboxylic acid;
- 3. Alcohol and ester;

- 4. Phenol;
- 5. Aldehyde.

496. According to the classification as bioorganic compound alginic acid is:
- 1. Amino acid;
- 2. Nucleic acid;
- 3. Homopolysaccharide;
+ 4. Heteropolysaccharide;
– 5. Wax.

497. Alginic acid is used in stomatology as:
+ 1. Irreversible hydrocolloid impression material;
- 2. Nonaqueous elastomeric impression material;
- 3. Inelastic impression material;
- 4. Direct restorative material;
- 5. Materials for filling of root canals.

498. Gutta percha is used in stomatology as:
- 1. Irreversible hydrocolloid impression material;
- 2. Nonaqueous elastomeric impression material;
- 3. Inelastic impression material;
- 4. Direct restorative material;
+ 5. Materials for filling of root canals.

499. Vulcanized rubber is used in stomatology as:
+ 1. material for abrasion and polishing instruments;
- 2. Nonaqueous elastomeric impression material;
- 3. Inelastic impression material;
- 4. Direct restorative material;
- 5. Materials for filling of root canals.

500. The mechanism of methyl methacrylate polymerization in presence of benzoyl peroxide is;
- 1. S_N;
- 2. A_N;
+ 3. A_R;
- 4. S_R;
- 5. S_E.

501. The watersolution of poly(acrylic acid)is characterized by:
- 1. neutral aqueous solution;

- 2. basic aqueous solution;
- 3. pH > 7;
+ 4. pH < 7;
- 5. pH=7.

502. Alginic acid is polymer of:
+ 1. betta-D-mannuronic acid and alpha-L-guluronic acid;
- 2. alpha-D-galacturonic acid;
– 3. betta-D-glucopyranose;
– 4. aspartic acid and glycine;
– 5. glutamic acid and lysine

503. Gutta percha is:
- 1. *Cis*-poly isoprene;
- 2. poly(methyl methacrylate);
– 3. polyethylene;
+ 4. *trans*-poly isoprene;
– 5. poly(methacrylic acid).

504. Rubber is:
+ 1. *Cis*-poly isoprene;
- 2. poly(methyl methacrylate);
– 3. polyethylene;
- 4. *trans*-poly isoprene;
– 5. poly(methacrylic acid).

TABLES

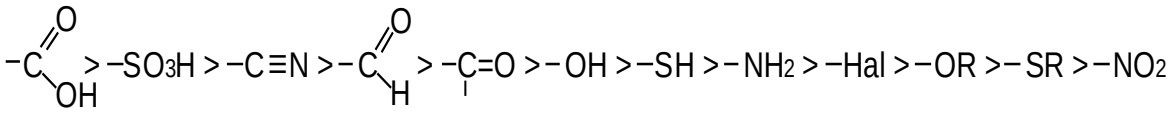
Alkyl groups

CH_3-	Methyl	All of these can be designated by R	
CH_3CH_2-	Ethyl		
$CH_3CH_2CH_2-$	Propyl		
$CH_3\underset{\vert}{C}HCH_3$	Isopropyl		

Nomenclature of the alkanes

NAME	NUMBER OF CARBON ATOMS	STRUCTURE	NAME	NUMBER OF CARBON ATOMS	STRUCTURE
Methane	1	CH_4	Heptadecane	17	$CH_3(CH_2)_{15}CH_3$
Ethane	2	CH_3CH_3	Octadecane	18	$CH_3(CH_2)_{16}CH_3$
Propane	3	$CH_3CH_2CH_3$	Nonadecane	19	$CH_3(CH_2)_{17}CH_3$
Butane	4	$CH_3(CH_2)_2CH_3$	Eicosane	20	$CH_3(CH_2)_{18}CH_3$
Pentane	5	$CH_3(CH_2)_3CH_3$	Heneicosane	21	$CH_3(CH_2)_{19}CH_3$
Hexane	6	$CH_3(CH_2)_4CH_3$	Docosane	22	$CH_3(CH_2)_{20}CH_3$
Heptane	7	$CH_3(CH_2)_5CH_3$	Tricosane	23	$CH_3(CH_2)_{21}CH_3$
Octane	8	$CH_3(CH_2)_6CH_3$	Triacontane	30	$CH_3(CH_2)_{28}CH_3$
Nonane	9	$CH_3(CH_2)_7CH_3$	Hentriacontane	31	$CH_3(CH_2)_{29}CH_3$
Decane	10	$CH_3(CH_2)_8CH_3$	Tetracontane	40	$CH_3(CH_2)_{38}CH_3$
Undecane	11	$CH_3(CH_2)_9CH_3$	Pentacontane	50	$CH_3(CH_2)_{48}CH_3$
Dodecane	12	$CH_3(CH_2)_{10}CH_3$	Hexacontane	60	$CH_3(CH_2)_{58}CH_3$
Tridecane	13	$CH_3(CH_2)_{11}CH_3$	Heptacontane	70	$CH_3(CH_2)_{68}CH_3$
Tetradecane	14	$CH_3(CH_2)_{12}CH_3$	Octacontane	80	$CH_3(CH_2)_{78}CH_3$
Pentadecane	15	$CH_3(CH_2)_{13}CH_3$	Nonacontane	90	$CH_3(CH_2)_{88}CH_3$
Hexadecane	16	$CH_3(CH_2)_{14}CH_3$	Hectane	100	$CH_3(CH_2)_{98}CH_3$

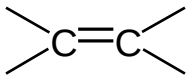
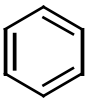
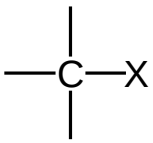
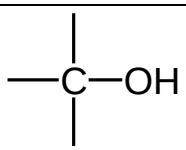
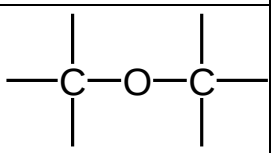
Groups seniority range

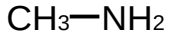
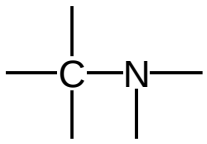
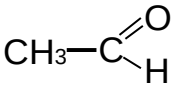
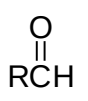
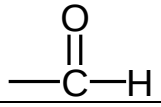
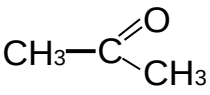
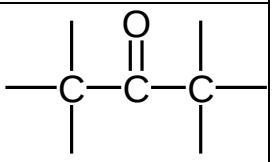
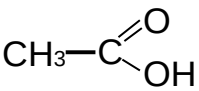
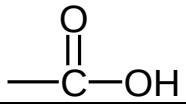
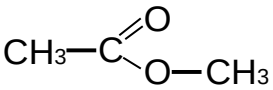
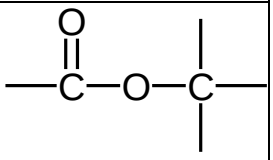
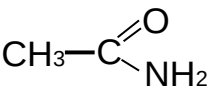
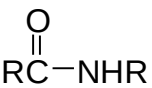
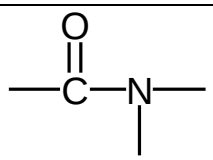


prefix	carboxy-	sulfo-	——	oxo-	oxo-	hydroxy-	mercapto-	amino-	halo-	alkoxy-	alkylthio-	nitro-
suffix	-oic acid	-sulfonic acid	-nitrile	-al	-one	-ol	-thiol	-amine	——	——	——	——

Seniority of groups decrease from left to right

Important families of organic compounds

Family	Specific example	IUPAC name	Common name	General formula	Functional group
Alkane	$H_3C—CH_3$	Ethane	Ethane	RH	C—H and C—C bonds
Alkene	$H_2C=CH_2$	Ethene	Ethylene	$RCH=CH_2$ $RCH=CHR$ $R_2H=CHR$ $R_2H=CR_2$	
Alkyne	$HC\equiv CH$	Ethyne	Acetylene	$RC\equiv CH$ $RC\equiv CR$	
Arene		Benzene	Benzene	ArH	Aromatic ring
Halo-alkane	$CH_3—CH_2—Cl$	Chloro-ethane	Ethyl chloride	RX	
Alcohol	$CH_3—CH_2—OH$	Ethanol	Ethyl alcohol	ROH	
Ether	$CH_3—O—CH_3$	Methoxy-methane	Dimethyl ether	ROR	

Amine		Methan-amine	Methyl-amine		
Aldehyde		Ethanal	Acetaldehyde		
Ketone		Propanone	Acetone		
Carboxylic acid		Ethanoic acid	Acetic acid		
Ester		Methyl-ethanoate	Methyl acetate		
Amide		Ethanamide	Acet-amide		

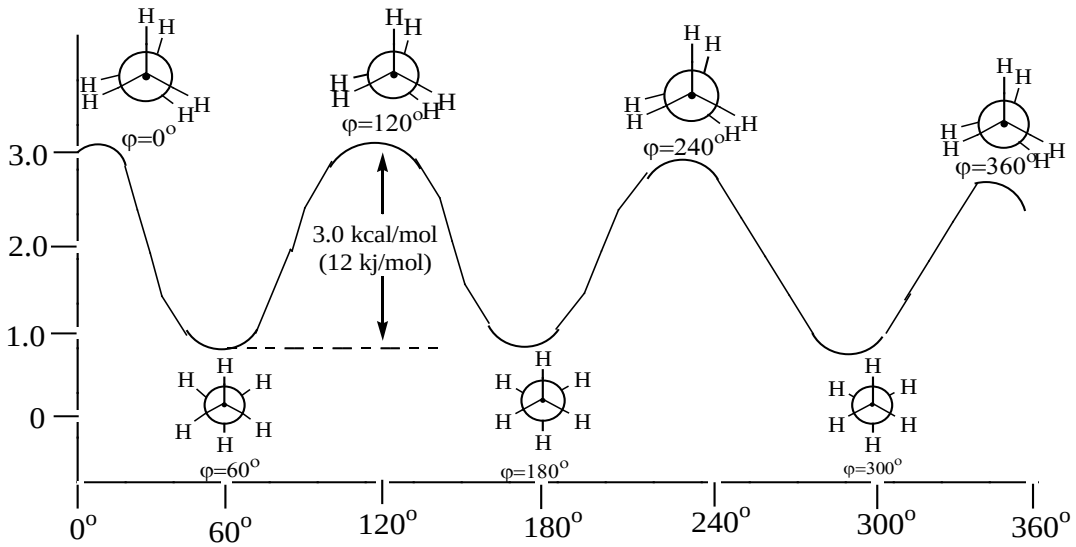
Electronegativities of some of elements

			H 2.1			
Li 1.0	**Be** 1.5	**B** 2.0	**C** 2.5	**N** 3.0	**O** 3.5	**F** 4.0
Na 0.9	**Mg** 1.2	**Al** 1.5	**Si** 1.8	**P** 2.1	**S** 2.5	**Cl** 3.0
K 0.8						**Br** 2.8

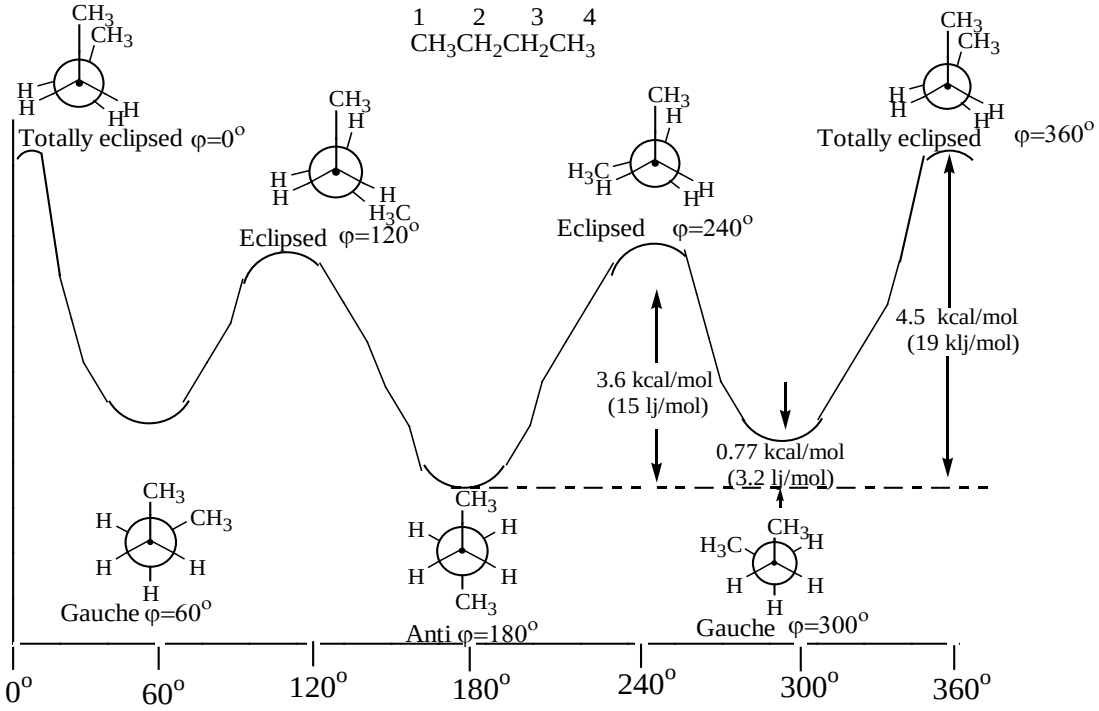
Classification of reagents

Electrophilic reagents		Nucleophilic reagents	
Positive charged ions	Neutral molecules	Negative charged ions	Neutral molecules
$H^{\oplus}$, $Br^{\oplus}$, $-C^{\oplus}-$ $NO_2^{\oplus}$ $SO_3H^{\oplus}$ $R\text{-}C^{\oplus}=O$	$-C^{\delta+}-X$ $O=S^{\delta+}=O$ O	$H^{\ominus}$, $Br^{\ominus}$, $HO^{\ominus}$, $RO^{\ominus}$ $HS^{\ominus}$, $RS^{\ominus}$	H_2O, ROH, RSH, NH_3, RNH_2

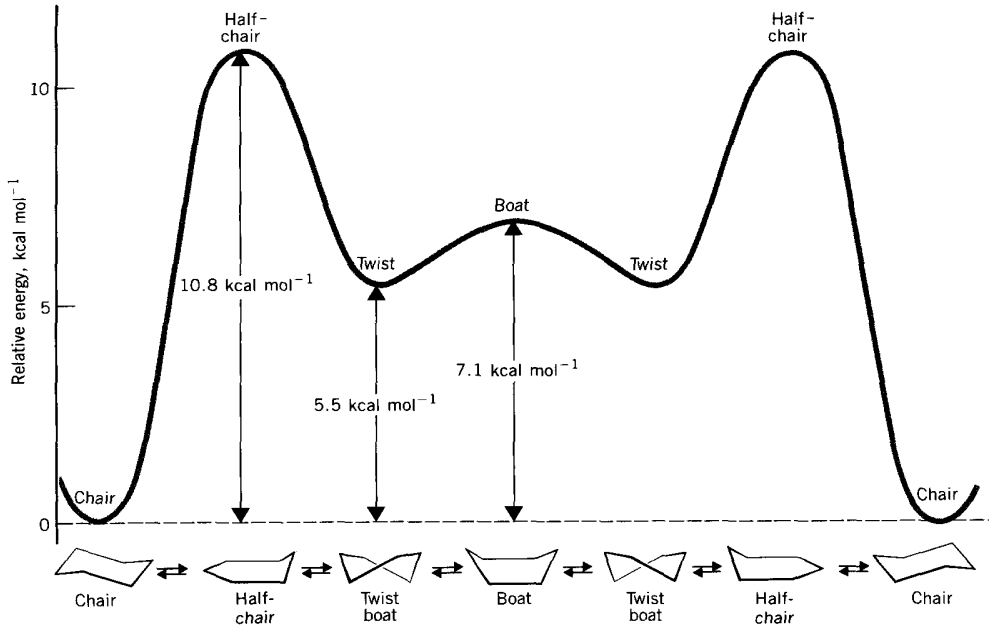
Conformations of ethane.



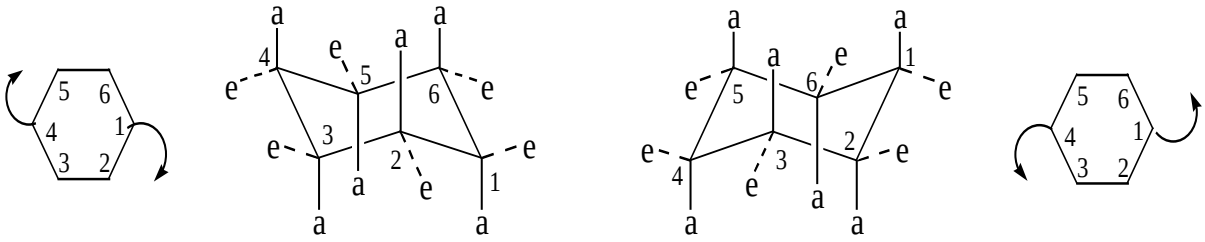
Conformations of butane



Conformations of cyclohexane

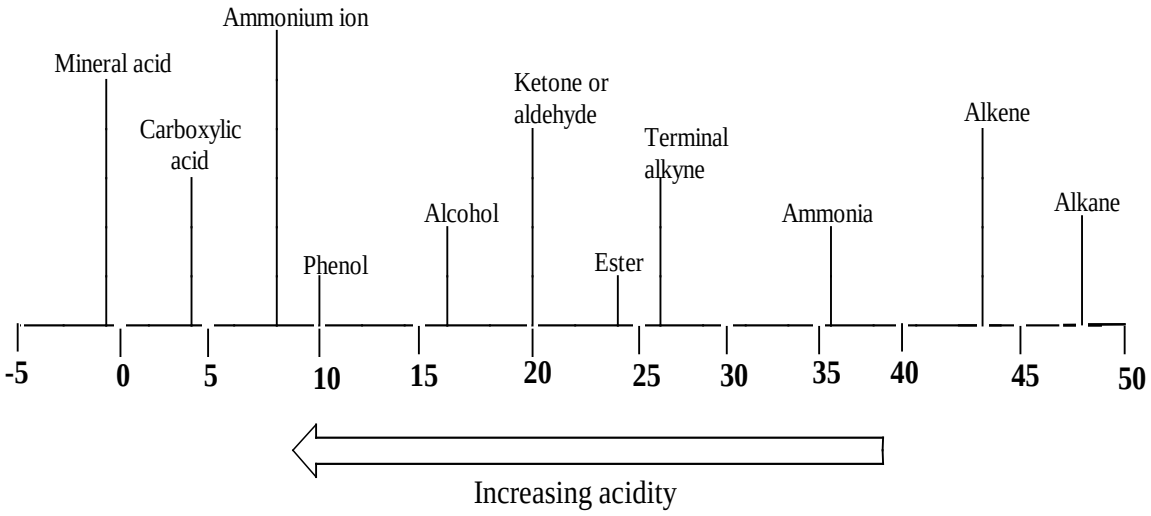


Chair conformations of cyclohexane.



$^{4}C_{1}$ conformation $_{4}C^{1}$ conformation

A graphical representation of pKa values for some of important categories of Bronsted-Lowry acids.



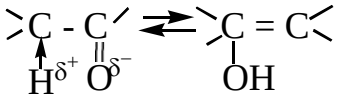
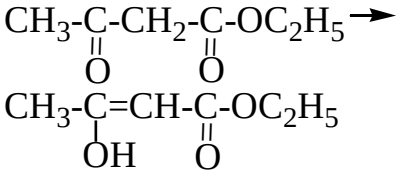
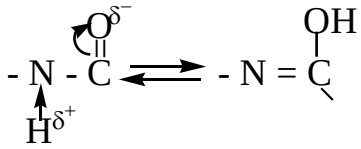
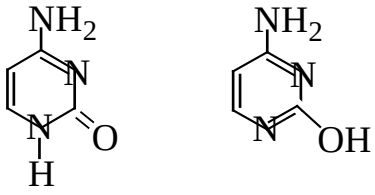
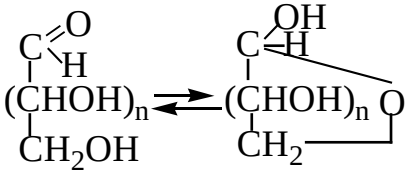
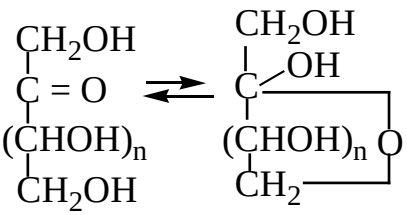
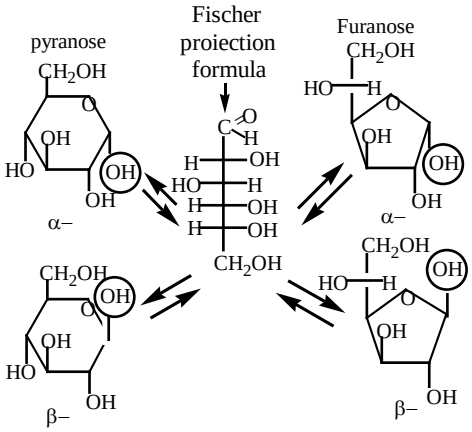
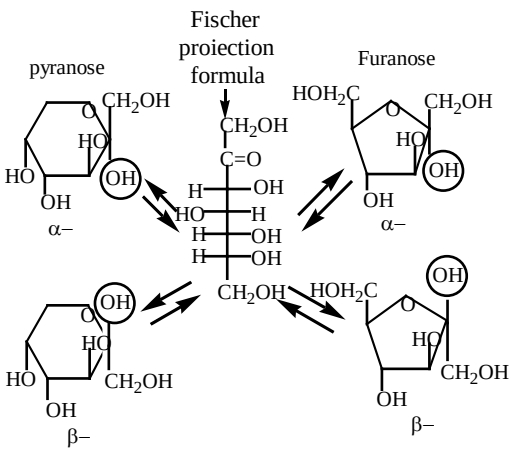
Relative strength of acids and their conjugate bases.

	ACID	APPROXIMATE pK_a	CONJUGATE BASE	
Strongest Acid	$HSbF_6$	> -12	SbF_6^-	Weakest Base
	HI	-10	I^-	
	H_2SO_4	-9	HSO_4^-	
	HBr	-9	Br^-	
	HCl	-7	Cl^-	
Increasing acid strength ↑	$C_6H_5SO_3H$	-6.5	$C_6H_5SO_3^-$	Increasing base strength ↓
	H_3O^+	-1.74	H_2O	
	HNO_3	-1.4	NO_3^-	
	CF_3CO_2H	0.18	$CF_3CO_2^-$	
	HF	3.2	F^-	
	CH_3CO_2H	4.76	$CH_3CO_2^-$	
	NH_4^+	9.2	NH_3	
	C_6H_5OH	9.9	$C_6H_5O^-$	
	$CH_3NH_3^+$	10.6	CH_3NH_2	
	H_2O	15.74	OH^-	
	CH_3CH_2OH	16	$CH_3CH_2O^-$	
	$(CH_3)_3COH$	18	$(CH_3)_3CO^-$	
	$HC{\equiv}CH$	25	$HC{\equiv}C^-$	
	H_2	35	H^-	
	NH_3	38	NH_2^-	
	$CH_2{=}CH_2$	44	$CH_2{=}CH^-$	
Weakest Acid	CH_3CH_3	50	$CH_3CH_2^-$	Strongest Base

Classification of substituents according to orientation characteristics.

Ortho-, para-orientants			Meta-orientants
Activating substituents (electron-donating groups)		Deactivating substituents (electron-acception groups)	Deactivating substituents (electron-acception groups)
+ I	+ M > - I	- I > + M	
- Alk (- CH_3, - C_2H_5 and so on)	- NH_2 - NHR - NR_2 - NHCOR - OH - OR	- F - Cl - Br - I	-C = N -COOH -COOR -C(=O)H -C(=O)R $-NO_2$ $-\overset{\oplus}{N}H_3$ $-\overset{\oplus}{N}R_3$ $-SO_3H$

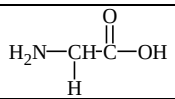
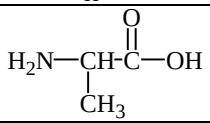
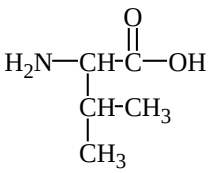
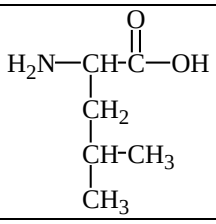
Tautomerism of organic compounds.

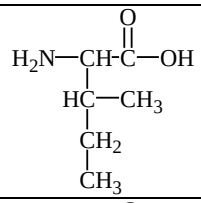
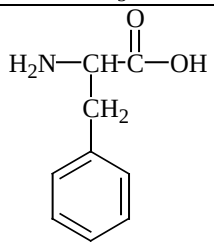
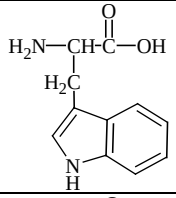
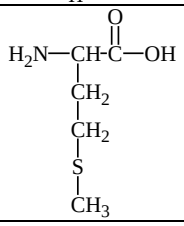
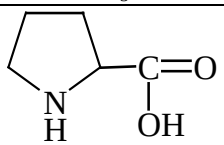
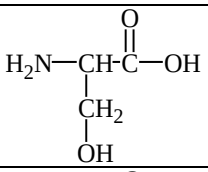
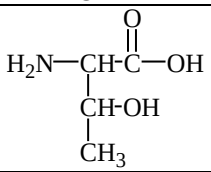
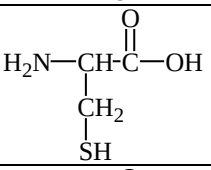
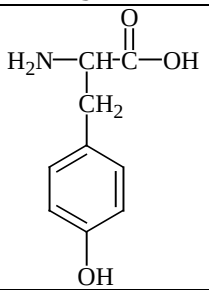
Tautomerism	Tautomerism equilibrium	Example
Keto-enol tautomerism		
Lactam-lactim tautomerism		
Cyclo-oxo tautomerism	Aldoses  Ketoses 	D-glucose  D-fructose 

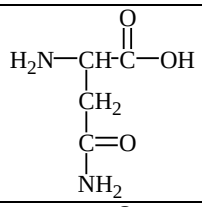
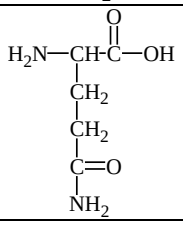
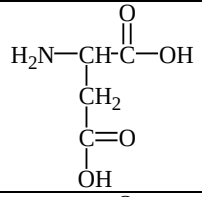
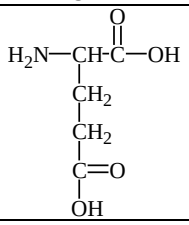
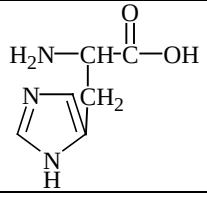
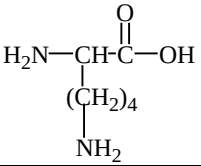
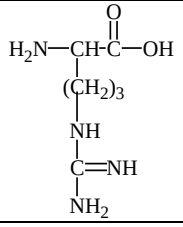
Nomenclature of di- and polysaccharides

Name	IUPAC name
Sucrose	α-D-glucopyranosyl-1,2 β-D-fructofuranoside
Maltose	4-O-(α-D-glucopyranosyl)-α, β-D-glucopyranose
Cellobiose	4-O-(β-D-glucopyranosyl)-α, β-D- glucopyranose
Lactose	4-O-(β-D-galactopyranosyl)-α, β-D- glucopyranose
Starch	Consist of amylose and amylopectin
a) amylose	$(\alpha\text{-D-glucopyranosyl-1,4})_n$-α, β-D- glucopyranose
b) amylopectin	$(\alpha\text{-D-glucopyranosyl-1,4})_n$-α, β-D-glucopyranose with branching α, 1→6
Glycogen	$(\alpha\text{-D-glucopyranosyl-1,4})_n$-α, β-D- glucopyranose with branching α, 1→6
Cellulose	$(\beta\text{-D-glucopyranosyl-1,4})_n$-α, β-D- glucopyranose
Chondroitin-4-sulfate	[D-glucuronic acid –β-1,3-N-acetyl-D-galactosamine-4-sulfate]$_n$
Heparin	[D-glucuronic acid –2-sulfate-β-1,4-N-sulfo-D-glucosamine-6-sulfate]$_n$
Hyaluronic acid	[D-glucuronic acid –β-1,3-N-acetyl-D-glucosamine]$_n$-[β-1,4-D-glucuronic acid-β-1,3-N-acetyl-D-glucosamine]$_m$

Structures of amino acids.

№	Name	Structure	Abbreviation	IUPAC name	pI
1. Non polar amino acids					
1.	Glycine		Gly	2-aminoethanoic acid	5,97
2.	Alanine		Ala	2-aminopropanoic acid	6,02
3.	Valine*		Val	2-amino-3-methylbutanoic ac-id	5,97
4.	Leucine*		Leu	2-amino-4-methylpentanoic acid	5,98

5.	Isoleucine*		Ile	2-amino-3-methylpentanoic acid	6,02
6.	Phenylalanine*		Phe	2-amino-3-phenylpropanoic acid	5,98
7.	Tryptophan*		Trp	2-amino-3(indolyl-3)-propanoic acid	5,88
8.	Methionine*		Met	2-amino-3-methyltiobutanoic	5,75
9.	Proline		Pro	Pyrrolidin-2-carboxylic acid	6,10
2. Polar amino acids					
1.	Serine		Ser	2-amino3-hydroxypropanoic acid	5,68
2.	Threonine*		Thr	2-amino-3-hydroxybutanoic acid	6,58
3.	Cysteine		Cys	2-amino-3-mercaptopropanoic acid	5,02
4.	Tyrosine		Tyr	2-amino-3(4-hydroxyphenyl)-propanoic acid	5,65

5.	Asparagine		Asn	2-amino-3-carbamoylpropano-ic acid	5,41
6.	Glutamine		Gln	2-amino-4-carbamoylbutanoic acid	5,65
3. Negative charged amino acids					
1.	Aspartic acid		Asp	2-aminobutandioic acid	2,97
2.	Glutamic acid		Glu	2-aminopentandioic acid	3,22
4. Positive charged amino acids					
1.	Histidine		His	2-amino-3-(imidozolyl-5)-propanoic acid	7,58
2.	Lysine*		Lys	2,6-diaminohexanoic acid	9,74
3.	Arginine		Arg	2-amino-5-guanidinopentanoic acid	10,7

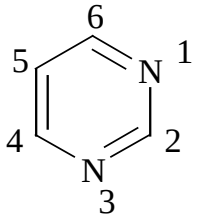
*** -** essential amino acids.

pK_a values for 20 common amino acids

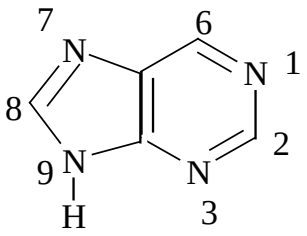
α-Amino Acid	$p(K_a)_1$ (α-COOH Group)	$p(K_a)_2$ (α-NH_3^+ Croup)	pK_{aR} (Side Chain Group)	pI
Alanine	2.3	9.9	-	6.0
Arginine	1.8	9.0	12.5	10.8
Asparagine	2.1	8.8	-	5.4
Aspartic acid	2.0	9.9	3.9	3.0
Cysteine	1.9	10.8	8.3	5.0
Glutamic acid	2.1	9.5	4.1	3.2
Glutamine	2.2	9.1	-	5.7
Glycine	2.3	9.8	-	6.0
Histidine	1.8	9.3	6.0	7.6
Isoleucine	2.3	9.8	-	6.1
Leucine	2.3	9.7	-	6.0
Lysine	2.2	9.2	10.8	9.8
Methionine	2.1	9.3	-	5.8
Phenylalanine	2.2	9.2	-	5.5
Proline	3.0	10.6	-	6.3
Serine	2.2	9.2	-	5.7
Threonine	2.1	9.1	-	5.6
Tryptophan	2.4	9.4	-	5.9
Tyrosine	2.2	9.1	10.1	5.7
Valine	2.3	9.7	-	6.0

Nomenclature of nucleic bases

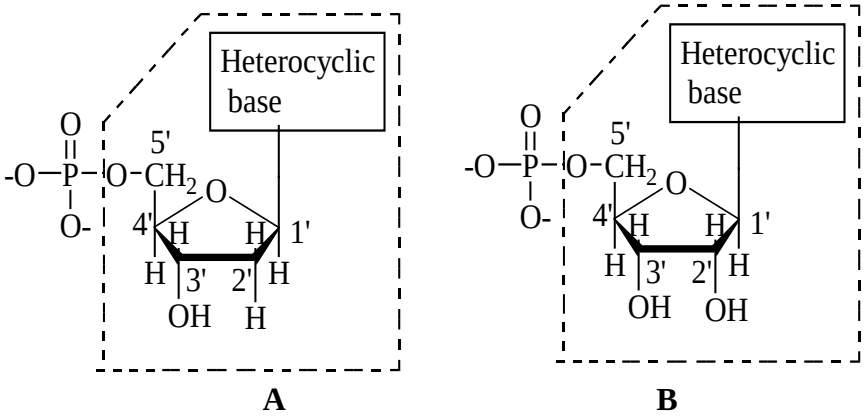
Name	IUPAC name
Adenine	6-aminopurine
Guanine	2-amino-6-hydroxypurine
Cytosine	4-amino-2-hydroxypyrimidine
Thymine	2,4-dihydroxy-5-methylpyrimidine
Uracil	2,4-dihydroxypyrimidine



Pyrimidine



Purine



The general structure of a nucleotide found in DNA and RNA.

Nomenclature of fatty acids

Name	Condense formula	IUPAC name
Myristic acid	(C_{14}); $C_{13}H_{27}COOH$	Tetradecanoic acid
Palmitic acid	(C_{16}); $C_{15}H_{31}COOH$	Hexadecanoic acid
Stearic acid	(C_{18}), $C_{17}H_{35}COOH$	Octadecanoic acid
Palmitooleic acid	(C_{16}); (Δ9); $C_{15}H_{29}COOH$	Cis – 9-hexadecenoic acid
Oleic acid	(C_{18}); (Δ9); $C_{17}H_{33}COOH$	Cis -9-octadecenoic acid
Linoleic acid	(C_{18}); (Δ9,12); $C_{17}H_{31}COOH$	Cis,cis-9,12-octadecadienoic acid
Linolenic acid	(C_{18}); (Δ9,12,15); $C_{17}H_{29}COOH$	Cis, cis, cis-9,12,15-octadecatrienoic acid

Literature:

1. L.G. Hidranovich. Bioorganic chemistry lecture course. Vitebsk, 2004.

2. Hurynava, A.S. Restorative dental polymer materials. Vitebsk, 2016.

3. T.W. Graham Solomons. Fundamentals of organic chemistry. John Willey and sons, 1994.

4. George H. Schmid. Organic chemistry. Mosby, 1996.

5. Richard F. Daley, Sally J. Dalley. Organic chemistry Wm. C. Brown Publishers, 1996.

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на английском языке

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